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PRE-FINAL DESIGN REPORT - ADDENDUM NO. 1
REVISED SECTION 6.0

12TH STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Prepared For:

Operable Unit No. 4 of the
Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

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6.0 DESIGN COMPONENTS

The design for the following components of the remedial action is described in this section:

- Site preparation
- Excavation of paper residuals from outside the landfill footprint
- Landfill grading
- Final landfill cover system
- Surface water management
- Landfill gas management
- Access road
- Institutional controls
- Abandonment of existing groundwater monitoring wells
- Installation of groundwater monitoring wells

6.1 SITE PREPARATION

Prior to excavating paper residuals outside the landfill footprint or the regrading of the landfill, the following activities will be performed:

- The physical condition of 12th Street (roadway area) will be reviewed and documented to ensure that the condition is maintained following completion of the construction activities.
- Silt fencing will be placed around the proposed excavation areas (Drawing C-03) to prevent the potential migration of sediment beyond the limits of construction as a result of surface water runoff. The silt fencing will be installed in accordance with the specifications contained in Appendix E of the RMT Pre-Final Design Report. In addition, soil errosison control measures will be conducted to meet the substantive requirements of a soil erosion control permit from Allegan County and a Notice of Intent with the State of Michigan.
- Brush and trees will be cleared and grubbed, as needed in the proposed excavation areas (Drawing C-02), including enough space for equipment to access the areas and for the staging of materials and equipment. Cleared vegetation will be chipped and taken off site.

- Existing groundwater monitoring wells, leachate head wells, landfill gas extraction wells, and staff gauges will be abandoned prior to performing grading and/or excavation activities as described in Section 8.1 of the RMT Pre-Final Design Report.
- A staging area for materials and office and equipment trailers will be established adjacent to 12th Street, outside the limits of paper residuals.
- A decontamination pad will be constructed at a location directly adjacent to the proposed final limits of paper residuals at the 12th Street Landfill.
- Temporary access roads will be constructed as necessary to obtain access to the excavation and grading areas.
- Access agreements, redevelopment plans, and lines of communication will be established with the adjacent property owners.

6.2 EXCAVATION OF PAPER RESIDUALS OUTSIDE THE LANDFILL FOOTPRINT

The areal limits of visible paper residuals outside the footprint of the landfill on the MDNR property, the asphalt plant property, and in the wetlands were previously delineated based on information obtained by Geraghty and Miller and the U.S. EPA in 1994 and 2003, respectively (G&M, 1994b and U.S. EPA, 2004), and have been refined based on the findings of the pre-design investigation performed by Weyerhaeuser in 2008. A copy of the report documenting the pre-design studies (RMT, 2008e) is contained in Appendix A of the RMT Pre-Final Design Report. Based on the areal limits (Drawing C-02) and the thicknesses of visible paper residuals present in areas beyond the proposed final capped footprint of the landfill, an estimated total of 12,200 cubic yards (cy) of visible paper residuals needs to be excavated and relocated back into the landfill (200 cy from the MDNR property, 7,500 cy from the asphalt plant property, and 4,500 cy from the wetland).

The estimated volume of off-site paper residuals to be relocated within the footprint of the landfill was revisited as part of the overall review of the final design to verify the volume of material to be accommodated under the final cover system. The test pit and boring information was provided in Appendix A of the RMT Pre-Final Design Report, used to delineate both the horizontal and vertical extent of paper residuals. It should be noted that during the review of the volumes of off-site paper residuals, inferences were made based on historical information, therefore, the extents of paper residuals provided are approximate based on the best available information. The intent of the Remedial Action (RA) is to excavate the paper residuals with the limits of excavation based on a combination of visual evidence and confirmatory sampling. There it was not necessary to verify the assumptions used to develop the volumes prior to conducting the RA. The actual extent will be determined during the excavation activities.

A review of these logs showed paper residuals to be present beneath the asphalt plant property to a depth in excess of 10 feet (as indicated on the original RMT drawings), with these excessive depths being present in the current landfill embankment extending on to the asphalt plant property. However, paper residuals are not present to a depth of 10 feet over the entire delineated area on the asphalt plant property. In the northern and southern portions of this off-site area, the depth of paper residuals is approximately 2 feet and 4 feet, respectively, grading to over 10 feet in depth in the middle. An independent calculation of the excavation volume on the asphalt plant property, based on assigning areas to the various test pits and borings, resulted in an estimated excavation volume of approximately 7,300 cy, which is very close to the previous estimate of 7,500 cy.

The test pits conducted in the wetland area to the north and northwest of the landfill showed that the depth of paper residuals ranged from 8 inches to 3 feet (as indicated on the original RMT drawings), with the shallow depths being observed to the north and northeast and the depths of paper residuals increasing to the northwest as the toe of the landfill extends on to the asphalt plant property. It should also be noted that the depths of paper residuals decreased to zero (i.e., not present) as each test pit moved away from the toe of the landfill. The excavation volume was again independently checked by assigning areas to each of the test pits, which resulted in an estimated volume of approximately 2,300 cy, which is only half of the previous estimate of 4,500 cy. It would appear that the previous calculations must have assumed full depth of excavation from the landfill toe of slope to the defined limits of paper residuals, whereas the revised calculations recognized that the depths decreased to zero at the defined limits.

Finally, the test pits on MDNR property to the southeast of the landfill showed that the depth of paper residuals was approximately 8 inches along this entire property line. Similar to the wetland area to the north, the depths of paper residuals decreased to zero as each test pit moved away from the landfill toe of slope. The independently calculated excavation volume resulted in approximately 50 cy of paper residuals to be removed from the MDNR property and relocated to the 12th Street Landfill, which is considerably less than the previous estimate of 200 cy. However, similar to the wetland excavation volume calculation, this volume would double if the full depth of excavation was extended to the reported limit of paper residuals. In addition, some of the existing landfill slope extends on to the MDNR property, so the previous excavation volume of 200 cy likely included some of the required slope removal, as discussed below.

A recently completed topographic and property boundary survey of the 12th Street Landfill shows that the east/west running landfill property boundary with the adjacent MDNR property is actually up the landfill slope, resulting in more excavation than was originally envisioned when the off-site removal volumes were calculated by RMT (see revised Drawing C-01). As such, it is roughly estimated that the volume requiring excavation from the MDNR property and relocation into the landfill is likely more than double (400 to 500 cy) the amount identified previously.

As a result of the independent review of the calculated excavation volumes, the total volume should be slightly less than previously indicated. There would appear to be approximately 2,000 to 2,200 cy less volume to be removed in the wetlands, but possibly an additional 200 cy to be removed from the MDNR property. Therefore, the revised total excavation volume will likely decrease from the previous estimate of 12,200 cy to between 10,000 and 10,500 cy, a decrease of approximately 15 percent. It should be remembered that the removal of paper residuals will need to be verified by sampling on the asphalt plant property and the wetlands, so the actual excavation volume could be larger than anticipated. Therefore, the revised design has continued to use the previous excavation volume estimate of 12,200 cy for placement under the final cover system, effectively allowing for approximately 15 percent additional excavation should it be needed.

In addition to the calculated volumes of paper residuals beyond the 12th Street Landfill property, there would be an associated excavation volume within the landfill slope areas when the property boundary encroaches into the landfill footprint. This is particularly evident for the landfill slope on the north edge of the MDNR property, as the recently completed property boundary survey shows the property line to be almost halfway up the landfill slope on the north side of the MDNR property. As such, in addition to the calculated volume of paper residuals beyond the landfill footprint, there would be a larger volume of material to be excavated from the slopes on the landfill to pull the toe of slope back onto the landfill property. This extent of the slope excavation and the associated volume calculations will be discussed further in Section 6.3, Landfill Grading.

A similar situation occurs on the west side of the landfill, adjacent to the asphalt plant property. (It should be noted that the recently completed property survey did not show any major differences for the western property boundary adjacent to the asphalt plant property, as was observed for the property boundary for the MDNR property). In this situation, the west slope of the landfill veers slightly to the southwest and slowly crosses the property line such that by the southwest corner of the landfill the entire steep sloped area is no longer on the landfill property. It is not known how this steep sloped area looked prior to any landfill operations, but the discussion of historical operations in

Section 2.2.2 of the RMT Pre-Final Design Report states that "*prior to 1955, a portion of the property on which the 12th Street Landfill is located was a wetland*". As such, it is expected that the sloped area to the southwest (note the driveway into the asphalt plant property going diagonally down this slope) likely turned to the east and cut across the southern portion of the 12th Street Landfill connecting over to the northerly slope on the MDNR property on the other side of the landfill. Based on this information, it would not be expected that the sloped area near the southwest corner of the landfill would contain paper residuals, and as such would not need to be excavated.

It should be noted that work activities related to the excavation of paper residuals in the wetland areas would typically be regulated under Michigan Act 451, Part 301 (work in wetlands) and Part 31 (work in 100-year flood plains), and would require a joint permit from the MDEQ Land and Water Management Division and the U.S. Army Corps of Engineers. The work activities required for the wetland areas and within the 100-year floodplain will be conducted in accordance with the substantive requirements of the joint permit, and hence, a permit will not necessarily be obtained.

6.2.1 EXCAVATION OF PAPER RESIDUALS ON THE MDNR PROPERTY

Paper residuals on the MDNR property will be excavated and relocated within the proposed limits shown on Drawing C-02, initially based on visual confirmation and finally by verification sampling as described in Section 6.2.3. The paper residuals will be placed within the landfill in lifts not exceeding 12 inches.

Based on the previous investigations and the more recent topographic and property survey information, approximately 400 to 500 cy of visible paper residuals are estimated to be excavated and relocated back into the landfill from the MDNR property (Drawing C-02). As documented in the pre-design studies (RMT, 2008e) (copied in Appendix A of the RMT Pre-Final Design Report), where present, paper residuals on the MDNR property are visible on the ground surface, or covered with a thin (less than approximately 1 inch thick) layer of forest litter (e.g., decaying leaves and branches mixed with occasional topsoil). The paper residuals are light gray, and overlie a poorly graded yellowish-brown sand, and are less than 6 to 8 inches thick. Paper residuals are easily distinguishable from the native soil (grayish-brown topsoil and yellowish-brown sand) based on color and consistency. The water table on the MDNR property is more than 6 feet below ground surface (bgs), and will not be encountered during the excavation activities.

The required excavation and removal of paper residuals from the MDNR property will also require encroachment into the landfill slope to the north (but should not require any significant removal of the landfill slope to the west, as the recent property survey shows that the property line is approximately along the toe of the landfill on this side of the MDNR property). Referring to Drawing C-02, it can be seen that the property line extends as far into the landfill slope to the 718 elevation contour at the northwest corner of the MDNR property, which is more than 10 feet in elevation above the toe of slope elevation. Therefore, it is expected that this material may need to be relocated back on to the landfill, which would result in a 10-foot cut at the property boundary. The entire slope may be cut back further into the landfill if paper residuals are found at depth.

6.2.2 EXCAVATION OF PAPER RESIDUALS ON THE ASPHALT PLANT PROPERTY

Paper residuals on the asphalt plant property will be excavated and relocated within the proposed limits shown on Drawing C-02, initially based on visual confirmation and finally by verification sampling as described in Section 6.2.3. The paper residuals will be placed within the landfill in lifts not exceeding 12 inches.

Based on the previous investigations, approximately 7,500 cy of visible paper residuals are estimated to be excavated and relocated back into the landfill from the asphalt plant property (Drawing C-02). The area on the asphalt plant property requiring excavation (Drawing C-01) is divided into two areas based on site features. The northern portion of the excavation area is in the wetland that extends north of both the asphalt property and the landfill. The southern excavation area includes a portion of the western landfill sideslope (as discussed previously), the flatter area directly west of the landfill sideslope, a paved area, and the asphalt berm area.

The slope stability analyses are based on the assumption that the rate of fill placement will be relatively rapid and excess pore water pressures will develop. This assumption is considered conservative as the existing berms are comprised of sand and fly ash, relatively free draining soils. Even with this conservative assumption, a review of the slope stability results shows that the factors of safety, corresponding to critical slip circles passing through the existing slopes and the underlying native stratum, for the sections analyzed exceed the targeted value of 1.5. These results indicate that the existing slopes and underlying native soils will remain stable during placement of excavated materials on top of the existing landfill. However, the existing landfill slopes will be regularly monitored for any signs of instability such as bulge, seepage or appearance of cracks during the landfill raising works. Should signs of instability appear, work will be stopped in that section of the landfill, and suitable remedial measures will be implemented.

In the event that unexpected material is found during excavation activities which is not consistent with types of materials that are known to be present in the landfill, such as paper residuals, the material will need to be either sampled in place or appropriately staged and sampled to determine the appropriate method for addressing this material (e.g., incorporating it in the landfill footprint, off-site disposal, etc). The exact approach will need to be established in the field depending on the nature of the material discovered, however, the preference will be toward sampling in-place to determine the appropriate characterization provided such activities can be accommodated in the construction sequencing. If temporary staging is required, the staging will be conducted within the landfill footprint in an area which includes a temporary berm and lining material. The material will also be covered when not being accessed.

Northern Excavation Area on Asphalt Plant Property

In the wetland, and as documented in the pre-design studies (RMT, 2008e) (copied in Appendix A of the is RMT Pre-Final Design Report), where present, paper residuals are covered by approximately 6 inches of organic topsoil or a black silty sand. Paper residuals in the northern portion of the excavation area are gray, overlie peat, and are approximately 3.5 feet thick. Paper residuals are easily distinguishable from the native soil based on color and consistency. It is expected that the paper residuals, combined with the overlying topsoil or black silty sand, will be removed and placed on the landfill.

As needed, the sidewalls of the excavation will be sloped to maintain overall stability of the excavation. The sidewalls of the excavation along the landfill will be graded to a slope of 4 horizontal to 1 vertical (4H:1V) to maintain the stability of the excavation and the landfill (see Section 6.3.3 and calculations provided in Appendix B). Standing water or groundwater may be encountered during excavation activities. Under these conditions, the paper residuals will be temporarily stockpiled immediately adjacent to the excavation area (and within the silt fencing), where excess water can gravity-drain back into the excavation prior to transportation to the landfill. After transportation to the landfill, if the paper residuals are still too wet, they will be spread in thin lifts and allowed to air-dry, mixed with mulch or dryer fill materials generated from the landfill grading activities, or mixed with solidification agents (e.g., Portland cement).

Southern Excavation Area on Asphalt Plant Property

In the southern excavation area on the asphalt plant property, and as documented in the pre-design studies (RMT, 2008e) (copied in Appendix A of the RMT Pre-Final Design Report), where present, paper residuals are covered by varying amounts of granular fill and asphalt and these residuals are up to approximately 10 feet thick. At the extreme southern end of the off-site excavation area on the asphalt plant property, the depth of observed paper residuals reduced to only 2 feet bgs. Paper residuals are easily distinguishable from the fill material and asphalt based on color and consistency. However, it is likely that the paper residuals, combined with the overlying granular fill and asphalt layers, will be removed together and placed on the landfill.

A tarry material (likely asphalt) was found to be commingled with paper residuals at 4.5 feet bgs at Geoprobe® boring RDB-12, installed during the pre-design studies investigation. At various depths, petroleum odors are also noted. The source of the petroleum odors were not identified by RMT.

As needed, the sidewalls of the excavation will be sloped to maintain overall stability of the excavation. The sidewalls of the excavation along the landfill will be graded to a slope of 4H:1V to maintain the stability of the excavation and the landfill (see Section 6.3.3 and calculations provided in Appendix B). To the extent practical, and based on visual observation, granular fill/soil and asphalt overlying the paper residuals will be segregated from the paper residuals and stockpiled on the asphalt plant property in a nearby area to be designated by Wyoming Asphalt (the asphalt plant property owner). Excavated paper residuals containing petroleum-based odors will be placed in the landfill (and incorporated with the paper residuals placed under the final cover).

During the pre-design studies field investigation in June 2008, groundwater was encountered at a minimum of 3 feet bgs in this area. At this point in the design, whether groundwater will enter into the excavation and need to be removed from the excavation is unknown, but quite likely. Prior to the start of construction, the contractor performing the RA construction activities may elect to perform some field testing to confirm whether groundwater will be encountered and check the quality of such encountered groundwater. The RA contractor will be responsible for identifying and providing the names of a licensed transporter and disposal facility for off-site disposal in the event that water is encountered during excavation activities, and off-site disposal is needed. As applicable, the RA contractor will also be required to provide the sampling procedures that support acceptance at the disposal facility. All transportation and disposal sub-contractors will be required to meet applicable provisions of federal, state, and local regulations and codes. Once an acceptable transporter and disposal site are provided to

Weyerhaeuser and within a minimum of 2 weeks prior to implementation, the proposed transporter, disposal facility, and associated sampling requirements will be provided to the U.S. EPA.

As an alternate to off-site disposal of water encountered during excavation activities, the RA contractor may elect to manage the water on-site. On-site water management will consist of a system, which will store, treat, and discharge to the sanitary sewer system or to the wetlands under the substantive requirements of a National Pollutant Discharge Elimination System (NPDES) permit. The water handling and on-site storage system will address the following:

i) potentially contaminated surface water.

ii) water collected from construction excavations.

iii) groundwater and surface water entering excavation areas.

iv) surface water collected from temporary soil stockpiles.

v) wastewater from the personnel (not including sanitary wastewater) and equipment decontamination facilities.

Water that is collected from the above-mentioned sources will be collected and pumped to a 20,000-gallon frac tank for temporary storage. The influent frac tank will settle sediment from the water, therefore the RA contractor shall take care when pumping water from the influent frac tank into the treatment system. Once a sufficient volume of water has been collected, the water will be treated using an on-site water treatment system. The on-site wastewater treatment system will consist of bag filter or sand filtration followed by treatment through primary and secondary activated carbon adsorption units. The treated water will be pumped to a 20,000-gallon effluent storage frac tank. The treated effluent will be sampled by the RA contractor in the effluent storage frac tank prior to discharge. The RA contractor will provide a minimum of two 20,000-gallon effluent frac tanks so that sufficient storage capacity is available to prevent delay of the excavation activities. The design flow rate of the system will be approximately 50 gpm. The system will be provided with appropriate secondary containment.

Treated effluent will be discharged to the local sanitary sewer system or the wetland area north of the 12th Street Landfill once the treated water has been confirmed to meet the discharge requirements. The parameters for analyzing the effluent prior to discharge will be determined to ensure that the water meets the local municipality's Publicly Owned Treatment Works (POTW) pretreatment requirements or the requirements of an NPDES permit. The proposed discharge rate for the treated water will be determined based on the on-site water management option selected by the RA contractor. The rate and volume of discharges will be recorded by the RA contractor.

In the event that the surface water and groundwater cannot be treated on-site to meet POTW or NPDES discharge requirements, the water will be sent off-site to a commercial treatment facility. Water which requires off-site disposal, will be managed in accordance with applicable regulations as discussed above.

Paper residuals excavated from below the water table will be temporarily stockpiled immediately adjacent to the excavation area (within the silt fencing), where the material will be allowed to dewater (excess water can gravity-drain back into the excavation) prior to being transported to the landfill. After being transported to the landfill, if the paper residuals are still too wet to support additional fill, they may be spread in thin lifts (not exceeding 12 inches) and allowed to air-dry, mixed with mulched materials or dryer fill materials generated from the landfill grading activities, or mixed with solidification agents (e.g., Portland cement).

Oil/Natural Gas Pipeline on Asphalt Plant Property

An underground oil/natural gas pipeline that is owned by Major Pipeline, L.L.C. (Major Pipeline) but is not currently in service, is present in the area where paper residuals need to be excavated (Drawings C-01 and C-02). The Right-of-Way Agreement for this pipeline indicates that it was installed in approximately 1957. Based on discussions with a representative of Major Pipeline, the pipeline was installed in a trench approximately 3 to 5 feet below the then-current ground surface (which was likely in the wetland area) and backfilled with native soil. Historical aerial photographs suggest that paper residuals were placed over the backfilled pipeline. Major Pipeline will be contacted to mark the location of the pipeline in the field prior to any excavation work near the pipeline, and will be present on-site during the start of excavation activities, at a minimum. Although the pipeline is believed to be buried a minimum of 3 feet below (not within) the paper residuals, work in the vicinity of the pipeline will proceed cautiously using hand shoveling to locate the pipe, as needed.

6.2.3 VERIFICATION SOIL SAMPLING ON THE MDNR AND THE ASPHALT PLANT PROPERTIES

Upon completion of the excavation activities on the MDNR property and the asphalt plant property, to the visual extent of the distinguishable paper residuals, samples of the native soil at the base of the excavation will be collected and analyzed to confirm the adequacy of the excavation activities. This verification sampling will be used to demonstrate completion with the Michigan Part 201 Generic Residential Cleanup Criteria (GRCC) pursuant to the MDEQ's Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria (STM; MDEQ, 2002).

Soil samples will be collected using a systematic random sampling strategy. Based on the information obtained from the test pits that were excavated on the MDNR property and asphalt plant property as part of the pre-design studies conducted in 2008 (Appendix A), the estimated areal extent of paper residuals on the MDNR property is 3,700 ft^2 (0.085 acre), and the estimated areal extent of paper residuals on the asphalt plant property is approximately 32,000 ft^2 (0.7 acre). Using these estimates, and following the MDEQ's STM guidance, it is anticipated that nine soil samples will be collected in the excavation on the MDNR property and that 13 samples will be collected in the excavation on the asphalt plant property. These estimates may be low because they do not attempt to account for the surface area of the sidewalls of the excavations. The actual number of samples to be collected on each property will be reviewed following the completion of the excavations and will be adjusted (up or down) as needed to meet the STM guidance (refer to Note 3 in Table 6-1).

Soil samples will not be collected from a local background area, as is sometimes necessary, because the constituents of potential concern, PCBs and, for the asphalt plant property, petroleum-related VOCs, would not be expected to be present at background locations.

The following text describes how the sample locations will be determined, how the samples will be collected and analyzed, and the criteria to determine if sufficient material has been excavated.

Overview of Sampling Activities - The soil samples will be collected from the top 6 inches of the native soil below the surfaces of the excavation base and sidewalls, and analyzed for PCBs. On the asphalt plant property, samples will also be tested for VOCs. At least one sample will be collected from each sidewall of an excavation. Samples will be collected following the procedures described in Section 2.5 of the Multi-Area Field Sampling Plan (Appendix N). Samples for analysis of VOCs will be collected using the field methanol preservation method.

Upon completion of excavation to the visual extent of the distinguishable paper residuals on the MDNR property and on the asphalt plant property, the following activities will be performed:

- Estimate the total area for which verification of soil remediation is to be performed, including the base of the excavation and the sidewalls.
- Verify that the area is similar to that estimated based on the test pit investigations performed in 2008. If the total area is more (or less) than 10 percent of the preliminary estimates shown in Table 6-1, then recalculate the grid interval and the number of samples to be collected.
- Establish a sampling grid for the total area (modifying, by hand, a sampling plan figure as necessary to represent sidewalls), using the grid intervals provided in Table 6-1. In setting up the sampling grid, identify the most southwestern corner as the (0, 0) coordinates. Use the pre-selected coordinates of 5 feet east, 10 feet north, (5, 10) to locate the first sampling location. Collect all remaining samples from locations that are east and north from this first location by the grid interval distance. Adjust the grid as necessary to collect at least one sample from each sidewall.
- Describe the soil samples in the field using the Unified Soil Classification System;
- Collect the samples from the top 6 inches of native soil below the surface of the excavation base and the sidewalls using a stainless-steel trowel and standard soil sampling and decontamination procedures. In addition to collecting samples for PCB analysis, collect samples on the asphalt plant property for VOC analysis using the methanol preservation method (on the asphalt plant property, collect the samples for PCB and VOC analyses at the same grid point).

  Label the samples from the MDNR property "VSRDNR-1," to denote Verification of Soil Remediation, Sample 1, through "VSRDNR-9"(estimated). Label the samples from the asphalt plant property "VSRAP-1", through "VSRAP-13" (estimated), to denote Verification of Soil Remediation (see Table 6-1);
- Place the samples in coolers containing ice, and ship the samples via overnight delivery to the laboratory following chain-of-custody procedures.
- Analyze all samples for PCBs and, for the samples collected on the asphalt plant property (the "VSRAP" samples), analyze the samples for VOCs as well. The analytical methods and target detection limits are provided in the Multi-Area QAPP (RMT, 2008c; copied in Volume 2 of this report).

The samples will be submitted to the laboratory for quick-turn analysis (i.e., 24-hour) so that the results can be reviewed and the adequacy of the excavation verified before restoring the excavated areas. As necessary, additional excavation, followed by sample collection and analyses, may be performed.

Quality Control Samples - Collect one equipment rinsate blank and one field duplicate soil sample from each excavation (i.e., one on the MDNR property and one on the asphalt plant property). Identify the QC samples on the chain-of-custody records as QC1, QC2, etc. Record the true identify of the QC samples in the field log book. Submit the QC samples for analysis of the same parameters as the field samples.

Data Evaluation - The laboratory results will be validated to determine their acceptability in meeting the data quality objectives of the soil verification sampling program. If targeted constituents of potential concern are detected in any of the samples, use appropriate statistical methods, consistent with the MDEQ's STM guidance, to evaluate the environmental significance of any detections and the potential need to conduct additional excavation activities.

The applicable criteria are the lowest of the Part 201 GRCC in *Table 2. Soil: Residential and Commercial 1*, of the MDEQ's Remediation and Redevelopment Division's Operational Memorandum No. 1 (January 23, 2006), which are the criteria used for defining a facility under Section 324.20101(1)(o) of Part 201. For PCBs, the applicable criterion is 4 mg/kg, which is the criterion for direct contact.

Review the results of the sample analyses, and if appropriate, any statistical evaluations, with the U.S. EPA to confirm that the data quality objectives of the soil verification sampling have been met and that it is acceptable to restore the areas disturbed by the excavations.

6.2.4 RESTORATION OF DISTURBED AREAS

Once it is determined that the data quality objectives have been met on the MDNR and the asphalt plant properties, the disturbed areas will be restored to a condition agreed upon between Weyerhaeuser and the MDNR and Wyoming Asphalt, respectively. At a minimum, this will include placing fill, as needed, to promote positive drainage from the disturbed areas and the establishment of vegetation. Additional restoration activities may include the planting of trees on the MDNR property to replace trees that need to be removed as part of the excavation activities and/or restoring the paved area on the asphalt property that may be disturbed.

6.2.5 EXCAVATION OF PAPER RESIDUALS IN WETLAND NORTH OF THE LANDFILL

Paper residuals on the 12th Street Landfill property that are located in the wetland north of the landfill will be excavated and relocated within the proposed limits shown on Drawing C-02 based on visual confirmation, in accordance with the ROD. The paper residuals will be placed within the limits of paper residuals in lifts not exceeding 12 inches. No soil verification sampling will be performed on the 12th Street Landfill property.

The following text describes the paper residuals located north of the landfill and how the area will be restored.

Extent of Planned Excavations

Approximately 2,000 to 2,500 cy of visible paper residuals are estimated to be excavated and relocated back into the landfill from the wetland north of the landfill in the approximate area shown on Drawing C-02. As documented in the pre-design studies report (RMT, 2008e) (copied in Appendix A of the RMT Pre-Final Design Report), on the eastern half of the excavation areas, where present, paper residuals are visible on the ground surface, or covered by a thin (less than approximately 1 inch thick) layer of forest litter (i.e., decaying leaves and branches mixed with occasional topsoil). Paper residuals are light gray, they overlie topsoil or a poorly graded yellowish-brown sand, and they are a maximum of approximately 8 inches thick. Paper residuals are easily distinguishable from the native soil (dark-gray topsoil and yellowish-brown sand) based on color and consistency. During the pre-design studies field investigation in June 2008, the groundwater was found to be at or slightly below the ground surface in this area.

The underground oil/natural gas pipeline described in Section 6.2.2 is present in the wetland where paper residuals need to be excavated (Drawing C-01 and C-02). Historical aerial photographs suggest that paper residuals were placed over the pipeline. Major Pipeline will be contacted to mark the location of the pipeline in the field prior to work near the pipeline. Although the pipeline is believed to be buried a minimum of 3 feet below (not within) the paper residuals, work in the vicinity of the pipeline will proceed cautiously using hand-shoveling to locate the pipe, as needed.

Paper residuals in the western half of the excavation area are either at the ground surface or are covered with approximately 0.5 to 1.0 feet of organic topsoil. The paper residuals are gray, they overlie a yellowish-brown clayey organic soil or peat, and they are approximately 3 feet thick adjacent to the landfill and become thinner (less than

1/2-inch) near the limits of identified extent of visible paper residuals. Paper residuals are easily distinguishable from the native soil based on color and consistency.

The sidewalls of the excavation along the landfill will be shallow (less than 4 feet) and will be graded to a slope of 4H:1V to maintain the stability of the excavation and the landfill. Standing water and/or groundwater may be encountered during the excavation activities.

At this point in the design, whether groundwater will enter into the excavation and need to be removed from the excavation is unknown. Prior to the start of construction, the contractor performing the RA construction activities may elect to perform some field testing to confirm whether groundwater will be encountered and check the quality of such encountered groundwater. The RA contractor will be responsible for identifying and providing the names of a licensed transporter and disposal facility for off-site disposal in the vent that water is encountered during excavation activities, and off-site disposal is needed. As applicable, the RA contractor will also be required to provide the sampling procedures that support acceptance at the disposal facility. All transportation and disposal sub-contractors will be required to meet applicable provisions of federal, state, and local regulations and codes. Once an acceptable transporter and disposal site are provided to Weyerhaeuser and within a minimum of 2 weeks prior to implementation, the proposed transporter, disposal facility, and associated sampling requirements will be provided to the U.S. EPA.

Alternatively, if on-site water management is determined to be the most viable option for water management, the water will be stored, treated, and discharged in accordance with the details provided in Section 6.2.2.

Paper residuals excavated from below the water table will be temporarily stockpiled immediately adjacent to the excavation area (within the silt fencing), where the material will be allowed to dewater (excess water can gravity-drain back into the excavation) prior to being transported to the landfill. After being transported to the landfill, if the paper residuals are still too wet to support additional fill, they may be spread in thin lifts (not exceeding 12 inches) and allowed to air-dry, mixed with mulched materials or dryer fill materials generated from the landfill grading activities, or mixed with solidification agents (e.g., Portland cement).

Restoration of Disturbed Areas

Once the visible paper residuals are removed from the wetland north of the landfill, the area will be covered by the final cover and access road/ditch as shown on Detail 1 on

Drawing C-10 or restored by backfilling the excavation. The backfill material will be capable of sustaining vegetation similar to what exists adjacent to the excavation. Restored areas that are outside the proposed limits of the landfill final cover and the site access road/ditch will be revegation in accordance with the Construction Quality Assurance (CQA) Project Plan (Appendix C) and the Specifications (Appendix E).

6.3 LANDFILL GRADING

6.3.1 GRADING PLAN

As described in Section 4.3 of the RMT Pre-Final Design Report, during the Emergency Action in 2007, the entire eastern slope of the landfill along the Kalamazoo River was cut back to an approximately 5H:1V slope. A buffer zone was created along the former powerhouse channel by cutting back approximately 35 feet of the eastern slope of the landfill adjacent to the river. A clay barrier layer was also constructed along the base of the regraded eastern slope. Additional details regarding the landfill final cover are discussed in Section 6.4 of this report.

Following the removal of the visible paper residuals/sediment in the channel, the riverbank from approximately elevation 698.0 to 702.5 feet M.S.L. was regraded to a 3H:1V slope and covered by riprap (D_{50} of 9 inches), installed over a geotextile fabric. Upslope of the riprap (approximately elevation 703.0 feet M.S.L.), 6 inches of topsoil were placed across the bench (approximately 703.0 feet M.S.L.). From elevation 702.5 to 707.0 feet M.S.L. on the regraded 5H:1V sideslope, 6 inches of general fill material were placed on the eastern sideslope, overlain by 6 inches of topsoil. The topsoil was then covered by erosion control matting (Enkamat®, which is a three-dimensional nylon turf reinforcement mat made of nylon filaments joined at the intersections).

The topsoil and erosion control matting above elevation 702.5 feet M.S.L. will be removed and restored (i.e., reused) as part of the final cover placement.

The remaining sideslopes on the northern, eastern, and western sides of the landfill will be graded to a maximum of 4H:1V. The paper residuals along the MDNR property and the asphalt plant property boundaries will be pulled back a minimum of 14 feet from the property line to provide the space required to build an access road/ditch around the base of the landfill (Detail 4 on Drawing C-11).

Based on the proposed grading plan (Drawing C-05), and the results from the soil borings advanced into the landfill during the recently completed predesign studies investigation, approximately 22,000 cy (see summary provided in Appendix G) of material will be cut from the existing landfill sideslopes and relocated further into the landfill. Combined with the approximately 12,000 cy to be excavated from the off-Site areas, the landfill will be required to accommodate an additional 34,000 cy prior to capping. The relocated paper residuals will be placed on top of the existing landfill, as the northern, western, and southeastern landfill sideslopes are cut back to 4H:1V slopes. The eastern landfill sideslope along the Kalamazoo River will remain at 5H:1V, while the southern sideslope along 12th Street will be graded to an 8H:1V slope. The top of the landfill will be graded to a minimum 5 percent slope, as shown on Drawing C-05. The approximate fill height after regrading will be approximately 740 feet M.S.L., which is 7 feet higher than the current landfill and approximately 40 feet above the wetlands. As summarized in Appendix P, the total design volume beneath the cover system is approximately 36,000 cy, which is 2,000 cy more than the total excavation volume (off-Site and sideslopes), thus allowing for some additional excavation based on the confirmatory/verification sampling results.

6.3.2 GLOBAL SLOPE STABILITY EVALUATION

As part of the design review and subsequent re-design of the 12th Street Landfill cover system, a geotechnical investigation was carried out between May 6 and May 12, 2009. The purpose of the geotechnical investigation was to determine the composition and shear strength of the landfill materials and the shear strength of the off-site paper sludge materials. These geotechnical parameters are required for evaluating the stability of the completed landfill slopes and the sliding stability of the proposed landfill cover. A separate memorandum presenting the details of the recently completed geotechnical investigation is included in Appendix B – Slope Stability Calculations. The location of the boreholes installed during the geotechnical investigation are shown on Figure 1 of Appendix B.

A review of the landfill borehole logs (included with the geotechnical memorandum in Appendix B) shows that the depth of the landfill deposits (paper residuals) was 22 to 25.5 feet bgs in boreholes SB-1 to SB/GW-6, with the exception of SB/GW-2 and SB-5 which were terminated in the landfill deposits at a depths of 36 feet and 31.5 feet bgs, respectively. At boreholes SB-1, SB/GW-2, SB-3, SB-4 and SB-5, which are generally located along the top edge of the landfill slopes, sand (SB-1 to SB-4) and/or fly ash (SB-5) materials were encountered at the ground surface or below the topsoil layer. The sand and/or fly ash materials extend to depths of 9 to 20 feet bgs and are underlain by the paper sludge or paper sludge/sand mix materials which extend to the native deposits beneath the landfill. In borehole SB/GW-6, advanced close to the center of the landfill, there was a surficial sand layer of only 2 inches thick before paper sludge materials were encountered, which continued to a depth of 25.5 feet bgs before encountering native sand deposits.

The standard penetration test (SPT) "N" values of the paper sludge materials ranged from 1 to 11 blows per foot, indicating a state of consistency ranging from very soft to stiff. The moisture content in the paper sludge and paper sludge/sand mixtures ranged from 19 to 126 percent, indicating generally saturated conditions. The undrained shear strength of the paper sludge materials was tested through field shear vain tests (FVT), which showed that the peak undrained shear strength of the paper sludge and paper sludge/sand mixtures in the landfill ranged from 516 to 3095 pounds per square foot (psf), with more than half of the values ranging from 1290 to 1548 psf. This resulted in a sensitivity of 1 to 5, indicating that the landfill paper sludge has low to medium sensitivity.

Based on these results, global slope stability modeling was performed, as presented in the second technical memorandum by Inspec-Sol (Appendix B), to assess the potential effect of the moisture content and shear strength of the paper residuals on the stability of the landfill sideslopes following the excavation and relocation of paper residuals within the landfill and to meet the requirements of the State of Michigan solid waste management regulations (Part 115). The slope stability modeling was performed for the most critical slope configuration (4H:1V), conservatively assuming saturated fill conditions at near the landfill surface (using the results of the recent geotechnical investigation).

Cross-sections of the landfill depicting the existing and final closure conditions were selected for static slope stability analyses. The cross-sections were selected based on a combination of subsurface conditions and the above grade landfill slope geometry that would result in representative conditions. The cross-sections were analyzed for the existing and proposed (closure) conditions to determine the relative effect of the proposed expansion on the landfill slopes. It has been assumed for the purpose of the analyses that the slopes (following construction operations) will not be steeper than the proposed slope of 4H:1V.

Graphs of the slope stability analyses are provided on Figures A1 to A16, and are summarized in Table 6 in Appendix B. A review of the results shows that the targeted minimum factors of safety are achieved for the proposed conditions at the cross-sections analyzed using the estimated soil shear strength properties, except cross-section C-C where a factor of safety of 1.45 was achieved. In view of the conservative soil parameters assumed for the analysis and an overall improvement over the existing condition (factor of safety of 1.04), the marginally low factor of safety of 1.45 can be considered acceptable. As such no significant slope stability issues are anticipated for the side slopes constructed at 4H:1V, provided construction recommendations provided in the technical memorandum are followed.

Michigan solid waste regulations stipulate analysis of slope stability, but do not define a required factor of safety. Generally accepted geotechnical practice applies a factor of safety of 1.5 for "normal conditions" and 1.3 for "worst-case conditions". The worst-case conditions of complete saturation are not likely to occur because of the extent and thickness of the hydraulically conductive sand fill that comprises the landfill's existing cover and its proposed final cover. The sand will act as a preferential pathway to dewater and stabilize the residuals within the landfill such that they are not likely to remain saturated.

Pending the results of the ongoing direct shear box testing, cover system sliding stability analyses were performed using the infinite slope methodology for the critical interfaces between the geosynthetic layers and between geosynthetic layers and landfill soils or cover system soils. The interface shear strength parameters have been assumed based on the literature review and experience with similar components. The interface shear strength parameters used and the results of the analyses are presented in Appendix B. The analyses assumes no up lift pressures on the cover system. A review of results presented in Table 6 in Appendix B shows that for the assumed interface-shear strength parameters and conditions, the calculated factors of safety exceeds 1.5.

Although Weyerhaeuser does not plan to install a leachate collection system at the 12th Street Landfill, perched liquid may be present within the landfill, as described in the RMT report entitled "Documentation of the Pre-design Studies". Based on conclusions from previous subsurface investigations at the landfill (i.e., the Test Pit Investigation Technical Memorandum, Geraghty & Miller, 1994a), perched liquid was found in areas where high-permeable material (construction debris) overlies low-permeable material (paper residuals). Test pits will be excavated in these areas, and if present, perched leachate will be removed. Leachate seeps may also form, during the regrading of the landfill, in areas where perched leachate comes closer to the landfill surface. Leachate, if present, will be collected and containerized in frac tanks and disposed at a licensed publicly-owned treatment works (POTW) or managed on-site as discussed in Section 6.2.2.

6.3.3 EXISTING SLOPE STABILITY EVALUATION DURING EXCAVATION

In order to evaluate the effect of up to 10 feet deep excavation at the toe of the existing landfill on its west side, computer models of Sections A-A and B-B were analyzed by removing 10 feet of existing soils from the toe of the landfill. A review of the slope stability analyses, Figures A25 to A28 of Appendix B shows that factors of safety of 1.06 to 1.4 were obtained which are considered acceptable for the short term conditions, as the excavations will be backfilled as soon as practical. It is further noted that the slope stability models are two-dimensional, and therefore, are considered conservative as the length of the excavation parallel to the toe of the slopes will be limited to 10 feet as recommended in Appendix B.

6.4 FINAL LANDFILL COVER SYSTEM

To meet the requirements of the ROD (described in Section 4.2 of the original RMT report), a final cover system will be placed over the regraded landfill sideslopes and top portion of the landfill. The final cover has been designed to meet the following objectives:

- to prevent the release of PCBs to the environment
- to provide sideslope stability, flood protection, and erosion control
- to minimize infiltration of precipitation through the landfill
- to prevent migration of residuals or leachate from the landfill into the adjacent areas
- to eliminate direct contact hazards

The final cover will be designed to meet the relevant portions of the Michigan Solid Waste Landfill closure regulations pursuant to Part 115, Solid Waste Management, of the NREPA. The erosion protection provided will be sufficient to protect the containment system from a 500-year flood event.

Prior to constructing the final cover over the 5H:1V eastern sideslope, the existing 6-inch thick layer of topsoil along with the turf reinforcement mat (Enkamat®) that was installed during the Emergency Action in 2007, will be removed. The topsoil and Enkamat® were installed as an interim measure until the final cover was constructed.

The riprap and the clay barrier layer installed during the Emergency Action in 2007 will remain in place. As described in the Emergency Response Plan Design report (RMT, 2007a), the riprap and the clay barrier layer are permanent measures that will not be removed during the Remedial Action. Installation of these measures as part of the Emergency Action will allow for the rest of the final cover system to be installed above the elevation of the 2-year flood event (approximately 702.5 feet M.S.L.).

The final cover will be installed over approximately 6.8 acres of the 12th Street Landfill (Drawing C-03) and will consist of the following components from bottom to top (Detail 5 on Drawing C-11):

- A 6-inch select granular fill layer placed on top of the landfill as a suitable subgrade material for the final cover and a gas venting layer for the passive gas venting system. This layer will be capable of collecting landfill gas and conveying it to the passive venting system. Granular fill from an off-site source that has a minimum hydraulic conductivity of 1×10^{-2} centimeters per second (cm/s), and that does not contain gravel, retained on the Number 4 sieve (for protection of the 40-mil linear low-density polyethylene [LLDPE] geomembrane above) will be used to construct the fill layer.
- A 40-mil thick textured LLDPE geomembrane liner (barrier layer) will be placed over the select granular fill or the nonwoven geotextile fabric. The geomembrane liner will act as a barrier to minimize infiltration of precipitation into the residuals.

  In lieu of the PVC liner specified in the ROD, use of the 40-mil thick textured LLDPE geomembrane was previously proposed, and preliminarily accepted by the U.S. EPA (U.S. EPA 2008b). LLDPE meets the relevant portions of the Michigan solid waste management closure regulations pursuant to Part 115 and has a hydraulic conductivity on the order of 4.0×10^{-13} cm/s (Giroud and Bonaparte, 1989; as presented in U.S. EPA, 1994). In comparison, the hydraulic conductivity of PVC is on the order of 2.0×10^{-11} cm/s.

  Because PVC geomembrane is only manufactured as a "smooth" material, it does not develop a high interface friction range or adhesion with soil or other synthetic materials (e.g., nonwoven geotextile). This makes it difficult to create stable final slopes at the proposed 4H:1V to 5H:1V grades. Because an LLDPE geomembrane can be manufactured as a "textured" material, it is a more appropriate alternative for the steep sideslopes of the 12th Street Landfill. Using a textured LLDPE geomembrane will improve the interface friction angle and the adhesion between the geomembrane and the soil or synthetic material, while still providing an effective barrier to infiltration. This will increase the factor of safety against slippage along the liner/soil interfaces and ultimately provide more stable final cover slopes.

  As part of the pre-design geotechnical investigation, direct shear box testing was performed to determine the factor of safety against slippage along the critical geosynthetic (geomembrane/soil, geomembrane/geotextile, and geotextile/soil) and soil interfaces. The shear box testing utilized specific soil and geosynthetic materials that would be used for the 12th Street Landfill remedial action to represent the critical interfaces within the 12th Street Landfill final cover system. The resultant calculations determined the factors of safety above on the 4H:1V landfill sideslopes for the modeled "worst-case" conditions. The factors of safety for generally accepted geotechnical practice are 1.5 for "normal conditions" and 1.3 for "worst-case conditions".

Direct shear testing will be performed prior to construction to determine site-specific values for the paper sludge/geocomposite drainage net, paper sludge/40-mil LLDPE textured geomembrane, geocomposite drainage net/40-mil LLDPE textured geomembrane, 40-mil LLDPE textured geomembrane/12-ounce nonwoven geotextile, and the 12-ounce non-woven geotextile/select aggregate fill interfaces. The resultant interface slope stability calculations incorporating thedirect shear box testing results will be submited to the U.S. EPA.

- A geocomposite drainage material (geonet) will be placed above the 40-mil thick textured LLDPE geomembrane liner. A geonet can typically convey infiltrating surface water off of the final cover system more effectively than aggregate material. Also, a geonet comes with geotextile fabric surrounding the plastic grid core, so a separate geotextile fabric would not be required(with separate geotextile) or the alternative geonet.
- A 24-inch thick general fill layer will be placed above the geonet. This protective layer will be capable of sustaining the growth of nonwoody plants and will have adequate water-holding capacity.
- A 6-inch thick vegetative layer will be placed over the protective layer. This layer will be designed to promote vegetative growth, promote surface water runoff, and minimize erosion. Consistent with the future use of the land being an eco-park, the vegetative growth will consist of a mix of grasses and forbes (flowering plants) native to the area.

The final cover components describe above will be placed in accordance with the requirements of the Construction Quality Assurance (CQA) Project Plan (Appendix C) and the Specifications (Appendix E).

The final cover along the Kalamazoo River will tie into the clay barrier layer. The portion of the clay barrier layer that is disturbed as a result of tying the geomembrane barrier layer into the clay barrier layer, will be reconstructed and tested in accordance with the CQA Project Plan (Appendix C) and the Specifications (Appendix E). Prior to the connection of the final cover to the clay barrier layer along the Kalamazoo River, the portion of the north slope extending beyond the north limit of the previously constructed 5H:1V eastern sideslope (part of Emergency Action in 2007) will be relocated back on to the 12th Street Landfill during the other off-site material (paper residuals) relocation activities.

As shown in Appendix F, the riprap was designed to provide protection from the flow velocity (5.7 feet per second) of the 500-year flood event. Previously, approximately 260 linear feet of riprap were installed along the Kalamazoo River as part of the Emergency Response Action performed in 2007. The riprap was installed over a geotextile fabric from the base of the river up to elevation 703.5 feet M.S.L. (the elevation of the access road along the riverfront is 703 feet M.S.L.).

Upslope of the riprap, for the entire length of the proposed eastern landfill sideslope, erosion control matting (Enkamat®, which is a three-dimensional nylon turf reinforcement mat made of nylon filaments joined at the intersections) will be installed from approximate elevation 703 feet M.S.L. to approximately 707 feet M.S.L. (Drawing C-04 and Detail on Drawing C-12). Calculations contained in Appendix F show that the Enkamat® installed to an elevation of approximately 707 feet M.S.L. will meet the requirements of the ROD, which requires an erosion protection system to provide protection from a 500-year flood event and extend to a minimum elevation of 707.0 feet M.S.L. In addition, the transition area between the 12th Street Landfill property and the MDNR property (on the southern end of the eastern side of the 12th Street Landfill along the Kalamazoo River will be protected by erosion control matting.

6.5 SURFACE WATER MANAGEMENT

Temporary erosion and sedimentation controls will be installed prior to excavation and landfill grading activities and will be maintained until permanent erosion controls are in place. Temporary erosion and sedimentation controls will consist of silt fencing. Silt fences will be installed around the proposed excavation areas (Drawing C-03) to prevent the potential migration of sediment from the limits of construction as a result of surface water runoff. Silt fences will be visually inspected in accordance with Section 7.2. Trapped sediment will be excavated and placed into the landfill underneath the final cover. Sediment controls will be installed in accordance with the Specifications (Appendix E) and with the Guidebook of Best Management Practices for Michigan Watersheds (MDEQ, 1998).

In addition to the erosion protection along the eastern landfill sideslope (riprap and Enkamat®) described previously in Section 6.3, erosion caused by surface water runoff from the rest of the landfill final cover will be minimized by vegetating the final grades. Estimates of erosion from the landfill, using the Revised Universal Soil Loss Equation, are presented in Appendix G.

Surface water runoff on the west side of the landfill will be directed by a combined access road/ditch that discharges into the on-site wetland to the north. On the southern landfill slope, surface water will be diverted to the east through a shallow ditch that directs surface water around the MDNR property, discharging to the Kalamazoo River(Drawing C-07 and Detail on Drawing C-12). For the northern portion of the 12th Street Landfill, surface water will be allowed to sheet flow off the cover system into a combined shallow ditch/access road, with several V-notches in the outside of the ditch to allow discharge of the collected surface water into the wetlands to the north. The geocomposite drainage net that is part of the final cover will facilitate drainage of any infiltrating precipitation through the upper layers of the final cover soil to the perimeter ditches(Detail 5 on Drawing C-11). As a result of the subsurface water controls and diversion of most of the surface water via shallow ditches around the perimeter of the landfill, the flow rate of surface water that may discharge onto the adjacent MDNR property or asphalt plant property from the remaining side slopes beyond the limits of the final cover will be significantly less than under current conditions.

The PCSWMM.net model (SWMM v.5.0.013) was used to calculate storm water flows at ditch inlet locations for both the 25-year and 100-year storm events. The model is a widely accepted hydrologic and hydraulic computer-modeling program based on the United States Environmental Protection Agency's Stormwater Management Model (SWMM).

The storm water ditches were designed to convey the 24-hour/25-year storm event, with additional modeling completed for the 24-hour/100-year storm events. For efficiency, the access road and perimeter ditches have been integrated, which resulted in the dimensions of the road/ditch with a five-foot bottom width and 4H:1V side slopes. The bottom of the ditches were modeled to include a stone bottom to protect from damage associated with vehicular traffic (ATV's for sampling, etc). To ensure that the stone material remains in place and does not erode under high flow conditions, a perforated geoweb material will be incorporated into the granular surface, holding the stone within its "honeycomb" structure.

The ditch outlets consist of depressions approximately every 200 feet along the outside edge of the ditch(es) with the complete outside perimeter along the northern section of the landfill armoured with a turf reinforcement mat to protect against erosion. The ditch outlets will discharge to the wetland, with the extreme east end of the perimeter ditches discharging to the Kalamazoo River.

All modeling parameters and outputs are located in Appendix G.

6.6 LANDFILL GAS MANAGEMENT

6.6.1 GAS SYSTEM

As part of the pre-design activities, a field program was implemented to obtain direct information regarding the ability of the 12th Street Landfill to produce landfill gas (LFG) in its current condition. The results of this field testing program are the primary factor in the design of the gas collection system for the 12th Street Landfill. A modified Tier 3 testing program (based on U.S. EPA's Method 2E) was implemented to obtain site-specific information regarding potential LFG generation as well as gas quality (i.e., percent methane, carbon dioxide, and oxygen). This information assisted in the confirmation of the anticipated passive LFG collection system design, as outlined below.

Appendix A presents a detailed technical memorandum that discusses the field program, results, and calculations that were used in the development of the passive venting system. The following paragraphs present a brief summary of the LFG design.

The passive LFG collection system designed for the 12th Street Landfill will mitigate the potential buildup of gas under the final cover system. The design includes the placement of a 6 inch select granular fill layer placed on top of the landfill as a suitable subgrade material for the final cover and a gas venting layer for the passive gas venting system. This layer will be capable of collecting landfill gas and conveying it to the passive venting system. Granular fill from an off site source that has a minimum hydraulic conductivity of 1×10^{-2} cm/s, and that does not contain gravel, retained on the Number 4 sieve (for protection of the 40 mil LLDPE geomembrane above) will be used to construct the gas venting layer.

The predesign field activities confirmed the anticipated low LFG generation rate from the 12th Street Landfill. This is due to several factors including the type and age of the waste, the shallow depth of burial of the waste, as well as an elevated leachate mound within the waste.

The modified Tier 3 testing results are presented in Appendix A. The results indicated that the application of a low flow and vacuum condition (i.e., 30 cubic feet per minute [cfm] and 10 inches of water column [in. WC]) influenced the landfill site within a 3-hour testing period. The LFG quality decreased from the beginning of the test and continued in a downward trend for both methane and carbon dioxide concentrations. Conversely, the oxygen and balance gas concentrations increased during the same time period. This is indicative of a waste that is in the declining stages of methane production, and as a result the waste cannot generate enough LFG to maintain a steady-state condition. Subsequently, the field testing was conducted at a lower flow and vacuum rate to confirm this condition. A higher flow rate and vacuum was also applied to the extraction well. These additional tests resulted in a similar downward trend for methane and carbon dioxide and a greater upward trend for oxygen and balance gases. The methane generation potential, k, from the landfill was calculated to be 0.00002/year by using this information along with the calculation procedures outlined in the Tier 3 method. This is a significantly lower value than typically used in LFG modeling, which validates the lower than anticipated LFG production.

A flow rate of 30 cfm was used in the design calculations for the passive vent system since this represents the upper limit of flow from the 12th Street Landfill. From the 6-inch select granular fill layer, 4-inch polyvinyl chloride (PVC) schedule 40 riser pipes will be installed that will penetrate through the final cover liner system and vent any collected gas directly to the atmosphere. There are seven proposed gas vents for the 12th Street Landfill, or approximately one vent per acre.

Lastly, the potential pressures developed from the production of LFG (based on the testing results) have been incorporated into the passive gas venting system as well as the stability determination of the final cover system. The final design has incorporated a potential LFG pressure of approximately 15 in. WC for 4H:1V slopes, which is consistent with values found in literature (RG&A, 2008).

The passive gas vent locations will be monitored in accordance with the PSVP (Appendix D). Any modifications to the gas management system will be presented to the U.S. EPA for review and approval prior to implementation.

6.6.2 PERIMETER LANDFILL GAS MONITORING NETWORK

Natural features, including the wetlands and the Kalamazoo River, limit potential landfill gas migration pathways to the north and east of the landfill, respectively.

Following the construction of the final cover, gas monitoring probes will be installed along the southern side of the landfill property, along the boundaries with the MDNR property and 12th Street, and along the boundaries with the asphalt plant property to the west. The probes will be spaced approximately every 500 feet at the locations shown on Drawing C-06. A typical gas probe construction detail is shown in Detail 7 on Drawing C-11. The landfill gas monitoring probes will be monitored in accordance with the O&M Plan (Appendix J) and the PSVP (Appendix D), both contained in the RMT Pre-Final Design Report.

6.7 ACCESS/DITCH ROAD

An approximate 14-foot wide access road will be constructed around the much of the perimeter of the landfill and will be accessible from 12th Street (Drawing C-06). The access road is combined with the perimeter drainage ditches, with the bottom width being 5 feet to facilitate ATV vehicles for routine monitoring activities. In the event that larger vehicles require access around the perimeter of the 12th Street Landfill, the ditches have been designed to be shallow (1.5 feet in depth) and wide (14 feet in overall width), such that larger vehicles could utilize these ditches as access roads.

The access road will effectively be an extension of the cover system, except that the upper topsoil layer would be replaced with a granular stone layer, and will be constructed in accordance with the CQA Project Plan (Appendix C) and the Specifications (Appendix E), both contained in the RMT Pre-Final Design Report. The access road/ditch will be installed at a minimum elevation of 703 feet M.S.L. to allow for access during a 2-year flood event (702.5 feet M.S.L.). The access road will typically only be used for monitoring activities, so access will be essentially limited to all-terrain vehicles only. Along the Kalamazoo River on the eastern side of the landfill, there will be no ditch and the access road will continue as topsoil, plus Enkamat® (Detail 4 on Drawing C-12), in order to provide a more aesthetic view from the river and from the walking paths in the potential future eco-park. All surface water discharging from the east side of the landfill will sheet flow across the access road and discharge into the previously constructed rip rap embankment.

The access road/ditch will be widened approximately 3 feet at certain locations (Detail 4 on Drawing C-11) to allow for the installation of, and access to, gas probes and groundwater monitoring wells. Gates (Details 8 and 9 on Drawing C-12), designed to prevent vehicle access, will be installed at the access road entrance along 12th Street. Additional information regarding the gates is discussed in Section 6.8.2.

6.8 INSTITUTIONAL CONTROLS

6.8.1 DEED RESTRICTIONS

The ROD requires that deed restrictions be imposed on the 12th Street Landfill property as necessary to appropriately restrict future land use pursuant to Section 20120a (1)(i) of the NREPA (i.e., for "limited industrial" land use). The SOW states that Weyerhaeuser is to rely upon the Restrictive Covenant for the 12th Street Landfill property that was filed on April 23, 2004, and that, if any deed restrictions are needed on adjacent properties, Weyerhaeuser shall attempt to obtain such deed restrictions in accordance with Section IX of the Consent Decree. Although the SOW states that the Restrictive Covenant for the 12th Street Landfill was filed on April 23, 2004, the *Declaration of Restrictive Covenants and Environmental Protection Easement* was found to have been recorded by the Allegan County Registrar of Deeds on March 25, 2005. This document is included in Appendix K.

The March 25, 2005, *Declaration of Restrictive Covenants and Environmental Protection Easement* (Deed Restrictions) granted certain land use or resource use restrictions for the 12th Street Landfill property. These Deed Restrictions were granted by and between Plainwell, Inc., the MDEQ; and the U.S. EPA as a third-party beneficiary. Weyerhaeuser Company, as a subsequent title holder of the property, is subject to the requirements of the Owner in the Deed Restrictions.

In general, the Deed Restrictions prohibit uses of the property that are not compatible with the property's zoned industrial land use designation, the limited industrial land use category under Section 20120a(1)(i) of the NREPA, or other use that is consistent with the assumptions and basis for the cleanup criteria developed pursuant to Section 20120a(1)(i) of the NREPA. Specifically, the Deed Restrictions prohibit the following uses of the landfill property:

a) A residence, including any mobile home or factory-built housing, constructed or installed for use as residential human habitation.

b) A hospital for humans.

c) A public or private school for persons under 21 years of age.

d) A daycare center for children.

e) Any purpose involving residential occupancy on a 24-hour basis.

f) Any other use that would disturb or penetrate the landfill cover or erosion control system as set forth in the ROD.

The Deed Restrictions also prohibit the following activities on the landfill property:

- Any excavation, drilling, penetration, or other disturbance of the surface or subsurface soil on the property, except as necessary for compliance with the O&M Plan, or conducted in accordance with any work plan approved or modified by the U.S. EPA, with MDEQ concurrence.
- Any construction of building on the property unless plans are submitted to, and approved by, the MDEQ and the U.S. EPA.
- Any activity that may interfere with any element of the ROD, including the performance of the operation and maintenance activities, monitoring or other measures necessary to ensure the effectiveness and integrity of the remedy.

The Deed Restrictions also require that vegetation and other materials be kept clear of the permanent markers, and that all soil, media, and debris on the property be managed in accordance with the applicable requirements of Section 20120c of the NREPA; Part 111, *Hazardous Waste Management*, of the NREPA; Subtitle C of the RCRA; and other relevant state and federal laws.

As discussed in Section 2.3 of the RMT Pre-Final Design Report, following implementation of the remedial action, Weyerhaeuser is considering the development of an education-based natural park area on the 12th Street Landfill property. This educational "eco-park" would showcase the history of the Kalamazoo River in that area and highlight the adjacent wetland habitat. In concept, the eco-park may include walking paths on the landfill cover with signs at designated viewing areas that would describe the history and ecology of the area. Another potential future land use option being considered is to provide access to the township to extend a river walk along the eastern boundary of the landfill heading north through the 17 acres of wetland buffer that would connect the existing river walks in the cities of Plainwell and Otsego.

While no decisions have been made regarding the future use of the landfill, components of the remedy have been designed with the flexibility to accommodate possible future use of the property as an eco-park and/or to connect the existing Plainwell and Otsego River walks in front of the landfill.

Any future recreational use of the 12th Street Landfill property would be implemented only upon the U.S. EPA's approval, including appropriate modifications to the existing Deed Restrictions and possibly the ROD. Within the RD/RA process, the approximately 1 year into the O&M period, Weyerhaeuser may prepare a more detailed future land use concept and relevant human health risk assessment for presentation to the U.S. EPA; the MDEQ; and potential project stakeholders such as the MDNR, the cities of Plainwell and Otsego, and the U.S. Fish and Wildlife Service. The input of the stakeholder group would be incorporated into a final land use plan for review and approval by the U.S. EPA.

6.8.2 FENCING AND GATES

Fencing and gates (Details 8 and 9 on Drawing C-12) will be installed along 12th Street (Drawing C-04) and along a short portion of the asphalt property and MDNR property boundaries to deter pedestrians and vehicular traffic from entering the landfill by simply going around the ends of the fence. The fencing and gates are consistent with existing access restrictions and likely restrictions that would be needed for a potential eco-park. If the U.S. EPA and/or Weyerhaeuser determines that an eco-park is not an appropriate land use for the landfill property, Weyerhaeuser will submit a plan to the U.S. EPA to install additional fencing consistent with the ROD.

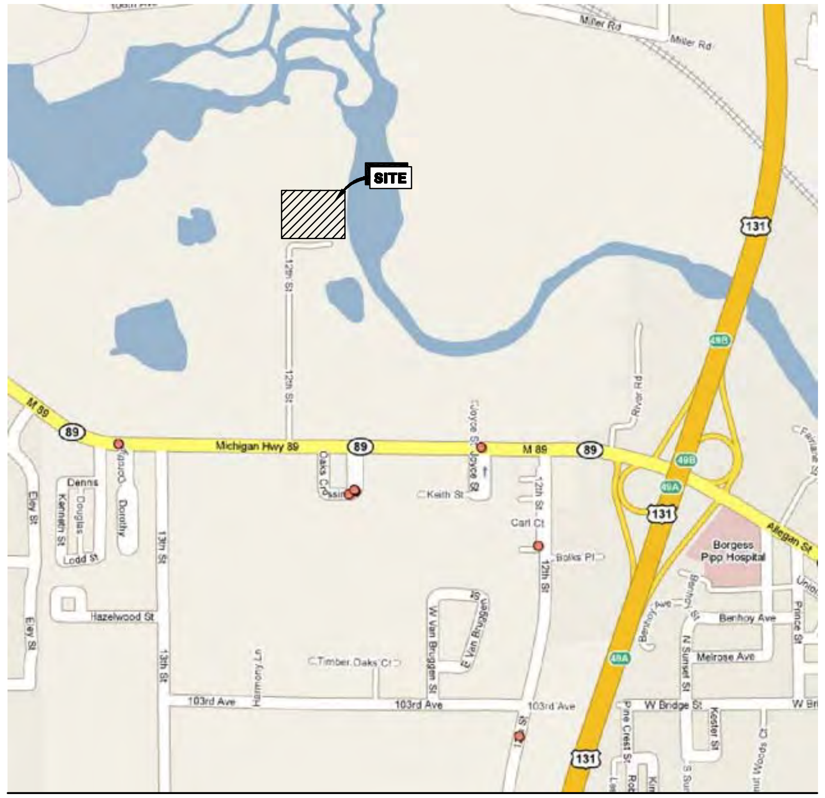
In accordance with the ROD, permanent markers will be placed along the property boundaries describing the area of the OU-4 and the nature of any restrictions. Warning signs will also be posted on the fence every 200 feet and on all entry gates. The number, content, and location of the permanent markers and warning signs will be presented to the U.S. EPA for approval prior to their installation.

6.9 PRELIMINARY CONSTRUCTION HEALTH AND SAFETY PLAN

A Preliminary Construction Health and Safety Plan (HSP) has been developed to protect field personnel and authorized site visitors during execution of the remedial action (Appendix L). The HSP has been prepared in fulfillment of the requirements that are contained in the CD and the SOW. A new HSP was submitted by Conestoga-Rovers & Associates (CRA) under separate cover on May 20, 2009 to address the RA construction activities and Remedial Investigation (RI) activities at Plainwell Mill. This HSP will be revised as needed to remain current with anticipated activities at both sites.

6.10 EQUIPMENT DECONTAMINATION

Decontamination of equipment utilized during the remedial action will be performed at a decontamination pad constructed at a location directly adjacent to the proposed final limits of paper residuals as discussed in Section 6.1 (refer to Section 6.1.3 of the FSP [RMT, 2008d]; copies in Appendix N of the RMT Pre-Final Design Report for additional information regarding the construction of the decontamination pad). Decontamination water will be collected and containerized and temporarily stored on-site as discussed in Section 6.2.2.



SOURCE: GOOGLE MAPS

KEY MAP
1:1000

DRAWING INDEX

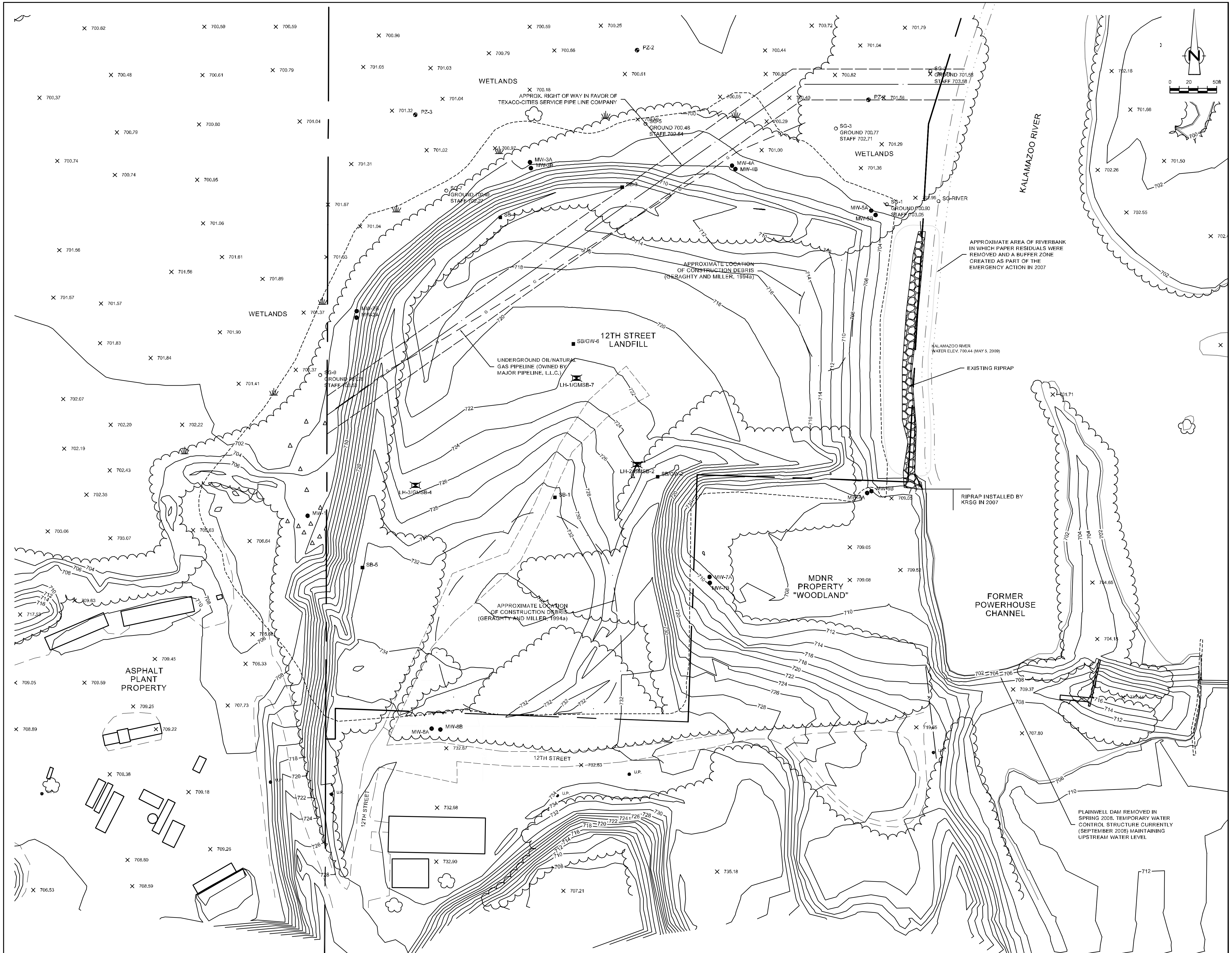
DWG. No.	REV. No.	DATE	TITLE
C-01	2	JUNE 2009	EXISTING SITE CONDITIONS
C-02	2	JUNE 2009	SITE WORKS
C-03	2	JUNE 2009	SOIL EROSION AND SEDIMENT CONTROL PLAN
C-04	2	JUNE 2009	SOIL EROSION AND SEDIMENT CONTROL DETAILS
C-05	2	JUNE 2009	SUBGRADE CONTOUR PLAN
C-06	2	JUNE 2009	PASSIVE GAS MANAGEMENT SYSTEM
C-07	2	JUNE 2009	FINAL CONTOUR PLAN
C-08	2	JUNE 2009	CROSS SECTIONS I
C-09	2	JUNE 2009	CROSS SECTIONS II
C-10	2	JUNE 2009	CROSS SECTIONS III
C-11	2	JUNE 2009	DETAILS I
C-12	2	JUNE 2009	DETAILS II

DESIGN DRAWINGS

PRE-FINAL DESIGN REPORT ADDENDUM No.1 (VERSION 3)

12th STREET LANDFILL
Otsego Township, Michigan

CONESTOGA-ROVERS & ASSOCIATES



Nº	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
2	UPDATED FOR THIRD EPA SUBMISSION	OCT. 19, 2009	C.R.H.

LEGEND

APPROXIMATE PROPERTY BOUNDARY
EXISTING PAVED ROAD
EXISTING UNPAVED ROAD
EXISTING FENCE
EXISTING BUILDING
700 EXISTING GROUND CONTOUR ELEVATION
x 715.1 EXISTING SPOT ELEVATION
EXISTING TREES AND/OR BRUSH
EXISTING WET AREA AND WETLAND
EXISTING EDGE OF WATER
EXISTING LIMITS OF PAPER RESIDUALS
APPROXIMATE LIMITS OF CONSTRUCTION DEBRIS
MW-1 EXISTING MONITORING WELL LOCATION
PZ-2 EXISTING PIEZOMETER LOCATION
LH-1/GMSB-7 EXISTING LEACHATE HEAD WELL LOCATION
SG-1 EXISTING STAFF GAUGE
EXISTING VANE SHEAR TEST LOCATION
SB-5 EXISTING INSPEC-SOL SOIL BORING LOCATION
SB/GW-6 EXISTING INSPEC-SOL SOIL BORING LOCATION/GAS WELL

NOTES:

1. BOUNDARY AND TOPOGRAPHIC SURVEY COMPLETED BY PREIN & NEWHOFF ON MAY 19, 2009.
2. THE APPROXIMATE LIMITS OF VISIBLE PAPER RESIDUALS WERE DERIVED FROM THE ALLIED PAPER, INC./PORTAGE CREEK / KALAMAZOO RIVER SUPERFUND SITE REMEDIAL INVESTIGATION, TECHNICAL MEMORANDUM 8, (G & M 1994b) AND REVISED BASED ON THE U.S.EPA'S 2003 PREDESIGN INVESTIGATION (U.S. EPA, 2004), THE EMERGENCY ACTIONS PERFORMED ALONG THE RIVERBANK IN 2007 (RMT, 2008b), AND THE PREDESIGN INVESTIGATION CONDUCTED IN JUNE 2008 (COPIED IN APPENDIX A OF THIS REPORT).
3. THE OIL/NATURAL GAS PIPELINE IS CURRENTLY (SEPTEMBER 2008) INACTIVE. IT WAS BURIED IN NATIVE SOIL PRIOR TO DISPOSAL OF PAPER RESIDUALS IN THE LANDFILL. THIS PIPELINE IS BURIED BELOW GRADE.

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

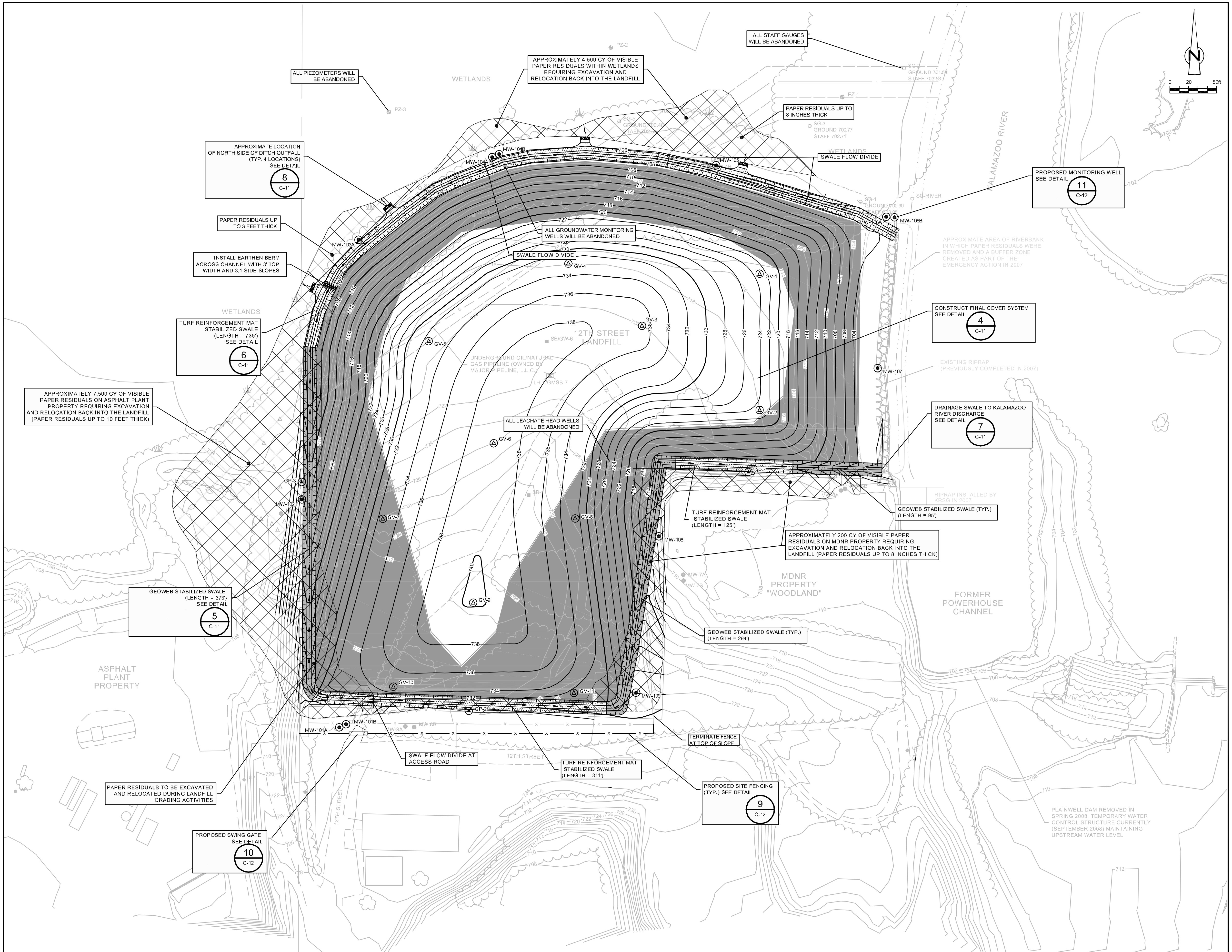
EXISTING SITE CONDITIONS

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
BASE ADAPTED FROM PREVIOUS RMT DESIGN

Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale: 1" = 50'-0"	Project Nº: 56393-05	Report Nº: 004	Drawing Nº: C-01

56393-05(004)CI-WA001 OCT 19/2009



Nº	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
2	UPDATED FOR THIRD EPA SUBMISSION	OCT. 19, 2009	C.R.H.

LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING FENCE
- EXISTING BUILDING
- 700 EXISTING GROUND ELEVATION CONTOUR
- EXISTING TREES AND/OR BRUSH
- EXISTING WET AREA AND WETLAND
- EXISTING EDGE OF WATER
- EXISTING LIMITS OF PAPER RESIDUALS
- MW-1 EXISTING MONITORING WELL LOCATION (TO BE ABANDONED)
- PZ-2 EXISTING PIEZOMETER LOCATION (TO BE ABANDONED)
- LH-1/GMSB-7 EXISTING LEACHATE HEAD WELL LOCATION (TO BE ABANDONED)
- SG-1 EXISTING STAFF GAUGE (TO BE ABANDONED)
- EXISTING VANE SHEAR TEST LOCATION
- SB-5 EXISTING INSPEC-SOL SOIL BORING LOCATION
- 718 PROPOSED FINAL ELEVATION CONTOURS
- PROPOSED FENCE
- PROPOSED ROAD/DRAINAGE SWALE c/w TURF REINFORCEMENT MAT
- PROPOSED ROAD/DRAINAGE SWALE STABILIZED WITH GEOWEB
- PROPOSED DRAINAGE SWALE OUTFALLS
- PROPOSED SLOPE CUT BACK
- MW-106B PROPOSED MONITORING WELL
- GV-1 PROPOSED GAS VENT
- GP-2 PROPOSED GAS PROBE

NOTES:

1. TWO CHANNEL LINING TYPES ARE PROPOSED. GEOWEB STABILIZED SWALE ARE PROPOSED FOR CHANNEL GRADES GREATER THAN 3.0%. ALL OTHER CHANNEL AREAS WILL BE LINED WITH PERMANENT TURF REINFORCEMENT MAT.

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

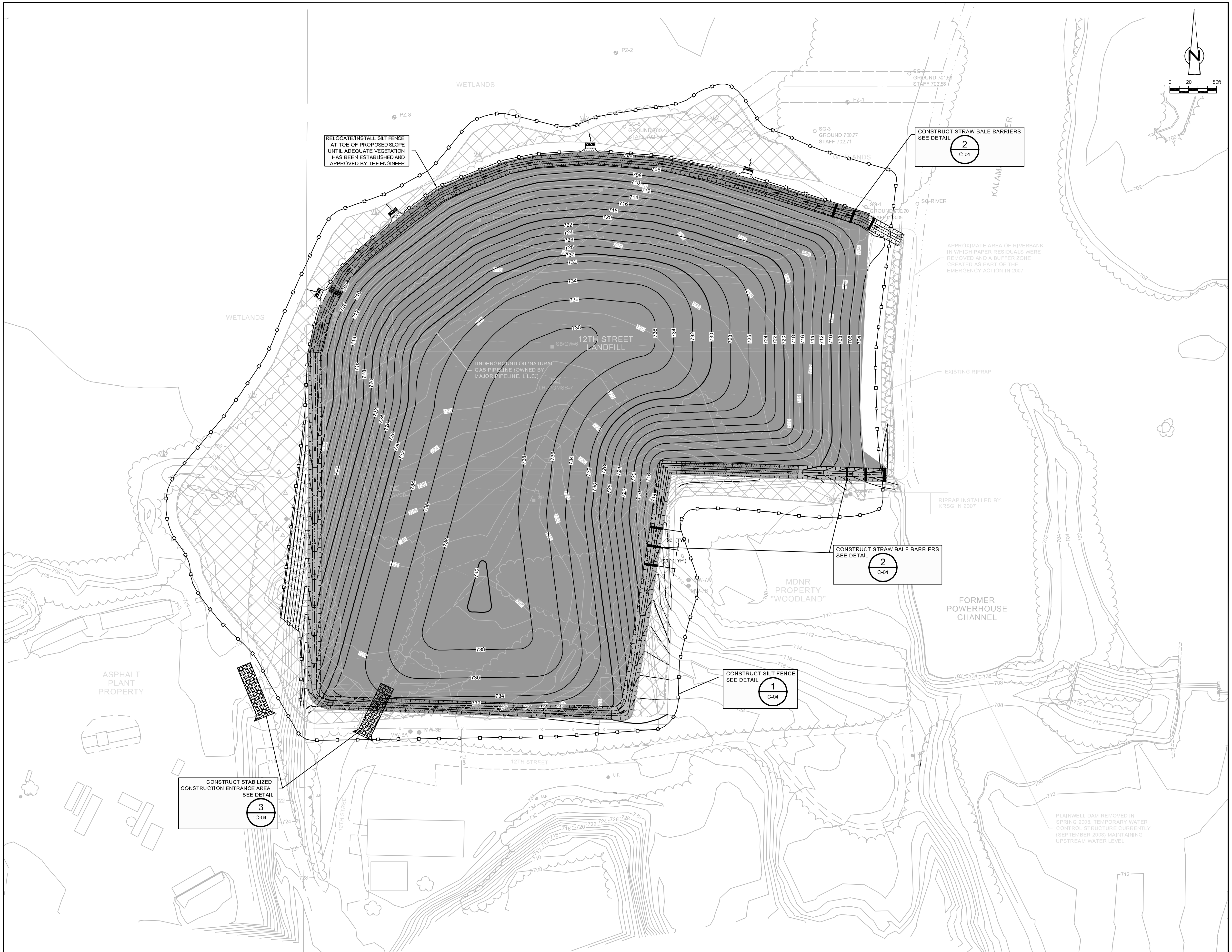
SITE WORKS

CONESTOGA-ROVERS & ASSOCIATES

Source Reference: BASE ADAPTED FROM PREVIOUS RMT DESIGN

Project Manager: G. CARLI	Reviewed By: R. HOEKSTRA	Date: JUNE 2009	
Scale: 1" = 50'-0"	Project Nº: 56393-05	Report Nº: 004	Drawing Nº: C-02

56393-05(004)CI-WA002 OCT 19/2009



Nº	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
2	UPDATED FOR THIRD EPA SUBMISSION	OCT. 19, 2009	C.R.H.

LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING FENCE
- EXISTING BUILDING
- 700 EXISTING GROUND ELEVATION CONTOUR
- EXISTING TREES AND/OR BRUSH
- EXISTING WET AREA AND WETLAND
- EXISTING EDGE OF WATER
- EXISTING LIMITS OF PAPER RESIDUALS
- MW-1 EXISTING MONITORING WELL LOCATION (TO BE ABANDONED)
- PZ-2 EXISTING PIEZOMETER LOCATION (TO BE ABANDONED)
- LH-1/GMSB-7 EXISTING LEACHATE HEAD WELL LOCATION (TO BE ABANDONED)
- SG-1 EXISTING STAFF GAUGE (TO BE ABANDONED)
- EXISTING VANE SHEAR TEST LOCATION
- SB-5 EXISTING INSPEC-SOL SOIL BORING LOCATION
- EXISTING PAPER RESIDUALS (TO BE RELOCATED ON SITE)
- 718 PROPOSED FINAL ELEVATION CONTOURS
- PROPOSED SILT FENCE
- PROPOSED ROAD/DRAINAGE SWALE c/w TURF REINFORCEMENT MAT
- PROPOSED ROAD/DRAINAGE SWALE STABILIZED WITH GEOWEB
- PROPOSED STRAW BALE BARRIERS
- PROPOSED CONSTRUCTION ENTRANCE
- PROPOSED LIMITS OF CAPPING
- PROPOSED DRAINAGE SWALE OUTFALLS

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

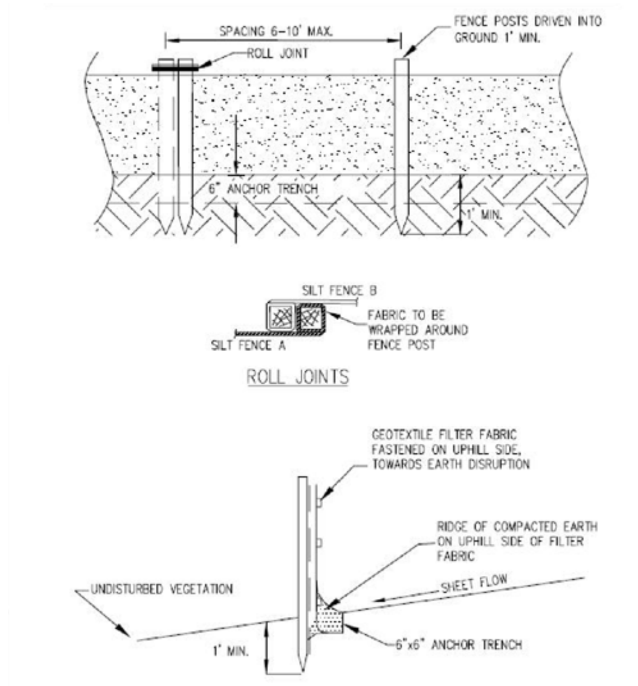
SOIL EROSION AND SEDIMENT CONTROL PLAN

CONESTOGA-ROVERS & ASSOCIATES

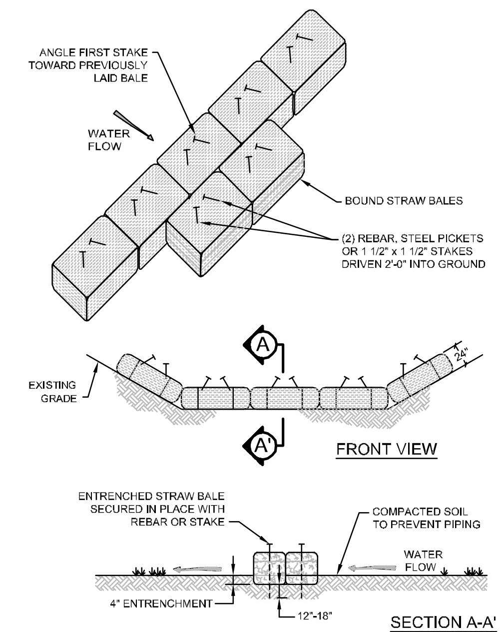
Source Reference:
BASE ADAPTED FROM PREVIOUS RMT DESIGN

Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale: 1" = 50'-0"	Project Nº: 56393-05	Report Nº: 004	Drawing Nº: C-03

56393-05(004)CI-WA003 OCT 19/2009



DETAIL 1 SILT FENCE
NTS
C-03



NOTE:
INSTALL SECOND ROW OF STRAW BALES IN BOTTOM OF SWALE ONLY.

DETAIL 2 STRAW BALE BARRIER
NTS
C-03

GENERAL NOTES FOR SOIL EROSION AND SEDIMENT CONTROL

1. THE CONTRACTOR SHALL BE RESPONSIBLE FOR CONSTRUCTION AND MAINTENANCE OF SOIL EROSION AND SEDIMENT CONTROL FACILITIES DURING CONSTRUCTION

2. AFTER THE PROJECT HAS BEEN COMPLETED, THE CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING THAT ALL PERMANENT SOIL EROSION AND SEDIMENT CONTROL MEASURES ARE IN PROPER WORKING CONDITION

3. SOIL EROSION AND SEDIMENT CONTROL SHALL INCLUDE, BUT NOT BE LIMITED TO, THE ABOVE MEASURES. THE CONTRACTOR SHALL BE RESPONSIBLE TO CORRECT ANY OMISSIONS, ERRORS, OR SUBSEQUENT FIELD OPERATION WHICH MIGHT DEVIATE FROM THE INTENT OF THIS PLAN. THE CONTRACTOR SHALL CORRECT SAID OMISSIONS, ERRORS OR FIELD OPERATION, IMMEDIATELY AND IN ACCORDANCE WITH THE ABOVE MENTIONED GUIDELINES.

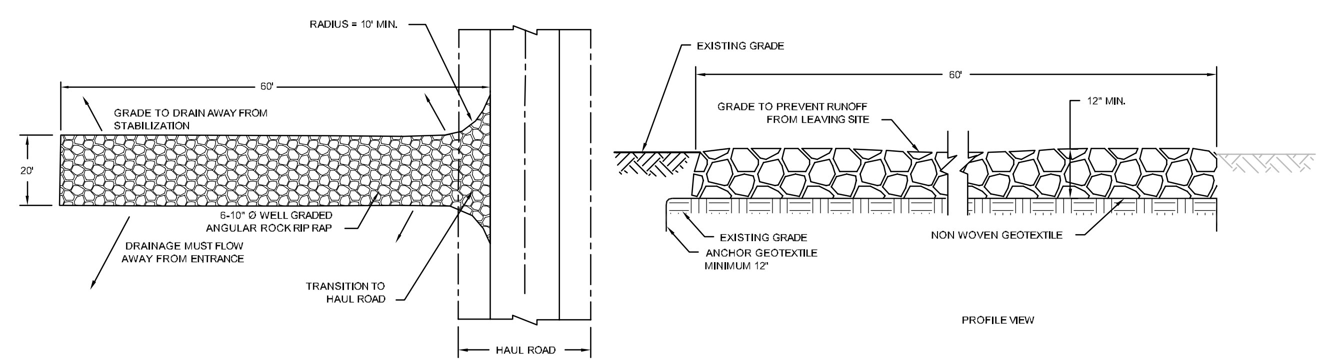
4. WHENEVER SEDIMENTATION IS CAUSED BY STRIPPING VEGETATION, REGRADING OR OTHER DEVELOPMENT, IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO REMOVE IT FROM ALL ADJOINING SURFACES, DRAINAGE SYSTEMS AND WATERCOURSES AND TO REPAIR ANY DAMAGE AS QUICKLY AS POSSIBLE.

5. DURING CONSTRUCTION, THE SITE SHALL BE MAINTAINED AND LEFT EACH DAY IN A SAFE AND SANITARY MANNER AND ANY CONDITION WHICH COULD LEAD TO PERSONAL INJURY OR PROPERTY DAMAGE SHALL BE IMMEDIATELY CORRECTED BY THE CONTRACTOR.

6. PRIOR TO OR DURING CONSTRUCTION, THE ENGINEER MAY REQUIRE THE INSTALLATION OR CONSTRUCTION OF IMPROVEMENTS TO PREVENT OR CORRECT TEMPORARY CONDITIONS ON THE SITE WHICH COULD CAUSE PERSONAL INJURY, DAMAGE TO PROPERTY OR CONSTITUTE A HEALTH HAZARD. THESE CONDITIONS MAY RESULT FROM EROSION OR LANDSLIDE, FLOODING, HEAVY CONSTRUCTION TRAFFIC, CREATION OF STEEP GRADES OR POLLUTION. IMPROVEMENTS MAY INCLUDE BERMS, GRADING, PLANTING, CULVERTS, PIPES, TEMPORARY ROADS, AND OTHER MEASURES APPROPRIATE TO THE SPECIFIC CONDITION. ALL TEMPORARY IMPROVEMENTS SHALL REMAIN IN PLACE AND IN OPERATION UNTIL OTHERWISE DIRECTED BY THE ENGINEER.

7. THE CONTRACTOR SHALL EXERCISE CARE SO AS NOT TO TRACK MUD OR DEBRIS INTO ADJACENT OFF-SITE OR ON-SITE ROADS. THE ROADWAY SHALL BE SWEPT CLEAN DAILY OR AS NEEDED. PUBLIC ROADS SHALL BE MAINTAINED FREE OF MUD OR DEBRIS. LOOSE DEBRIS WILL BE REMOVED AT THE CONSTRUCTION ENTRANCE.

8. THE CONTRACTOR SHALL TAKE NECESSARY MEASURES TO ENSURE SURFACE WATER IS CONTROLLED ADEQUATELY TO PREVENT FLOODING IN WORK AREAS. THE CONTRACTOR MAY NEED TO IMPLEMENT ADDITIONAL SURFACE WATER CONTROL FEATURES SUCH AS UP-STREAM DIVERSION BERMS.



DETAIL 3 STABILIZED CONSTRUCTION ENTRANCE
NTS
C-03

Nº	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
2	UPDATED FOR THIRD EPA SUBMISSION	OCT. 19, 2009	C.R.H.

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

SOIL EROSION AND
SEDIMENT CONTROL DETAILS

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale:	Project Nº:	Report Nº:	Drawing Nº:
AS SHOWN	56393-05	004	C-04

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LEGEND

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- EXISTING VANE SHEAR TEST LOCATION
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- 718 PROPOSED SUBGRADE ELEVATION CONTOURS
- PROPOSED ROAD/DRAINAGE SWALE c/w TURF REINFORCEMENT MAT
- PROPOSED ROAD/DRAINAGE SWALE STABILIZED WITH GEOWEB

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

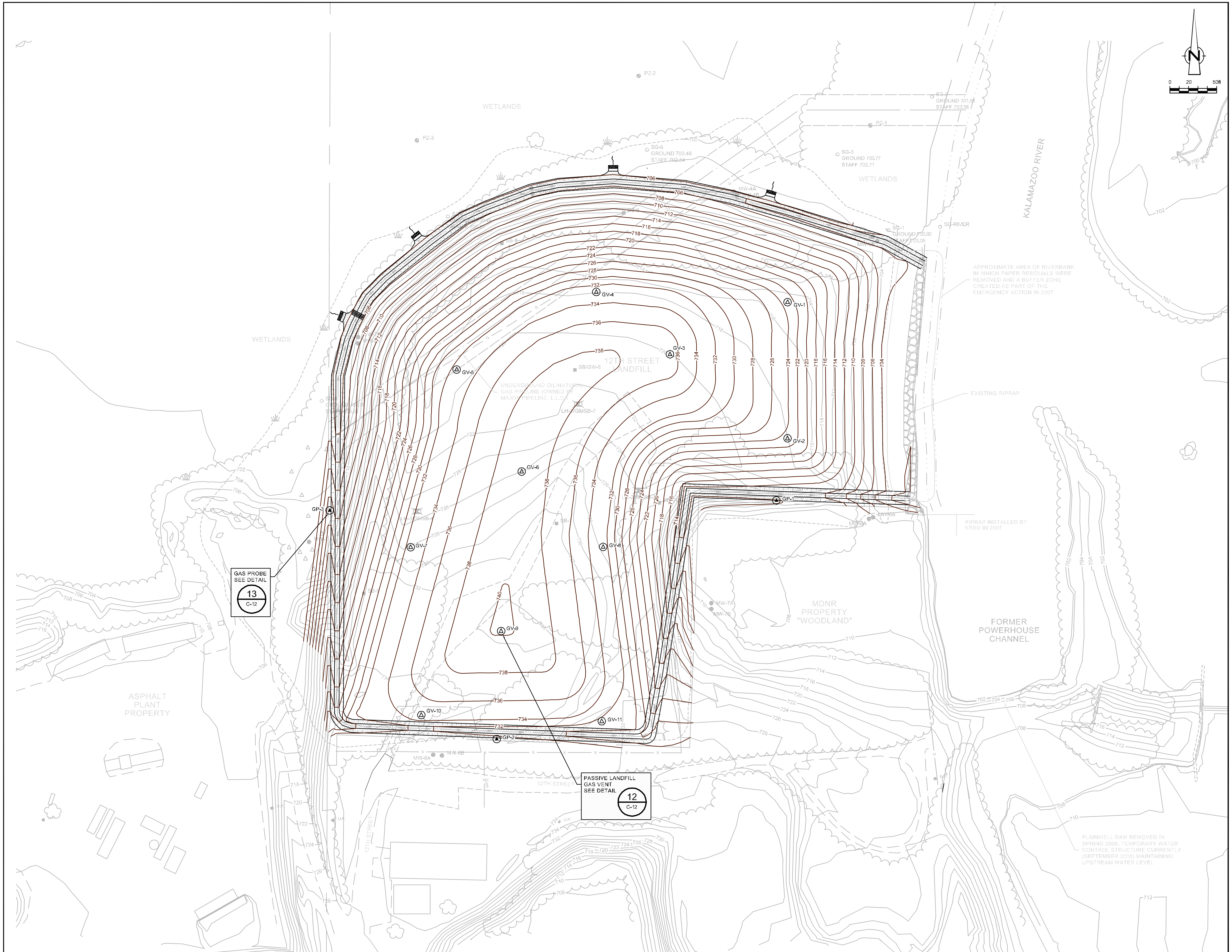
SUBGRADE
CONTOUR PLAN

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
BASE ADAPTED FROM PREVIOUS RMT DESIGN

Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale:	Project №:	Report №:	Drawing №:
1" = 50'-0"	56393-05	004	C-05

56393-05(004)CI-WA005 OCT 19/2009



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- EXISTING VANE SHEAR TEST LOCATION
- SB-5 EXISTING INSPEC-SOL SOIL BORING LOCATION
- 718 PROPOSED SUBGRADE ELEVATION CONTOURS
- GV-1 PROPOSED GAS VENT
- GP-2 PROPOSED GAS PROBE

NOTE:

1. PASSIVE VENT STRIPS TO BE SPACED AS SHOWN OR AT APPROXIMATELY 200-FOOT CONTERS AROUND LANDFILL PERIMETER.

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

PASSIVE GAS
MANAGEMENT SYSTEM

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
BASE ADAPTED FROM PREVIOUS RMT DESIGN

Project Manager:	Reviewed By:	Date:
G. CARLI	R. HOEKSTRA	JUNE 2009

Scale:	Project Nº:	Report Nº:	Drawing Nº:
1" = 50'-0"	56393-05	004	C-06

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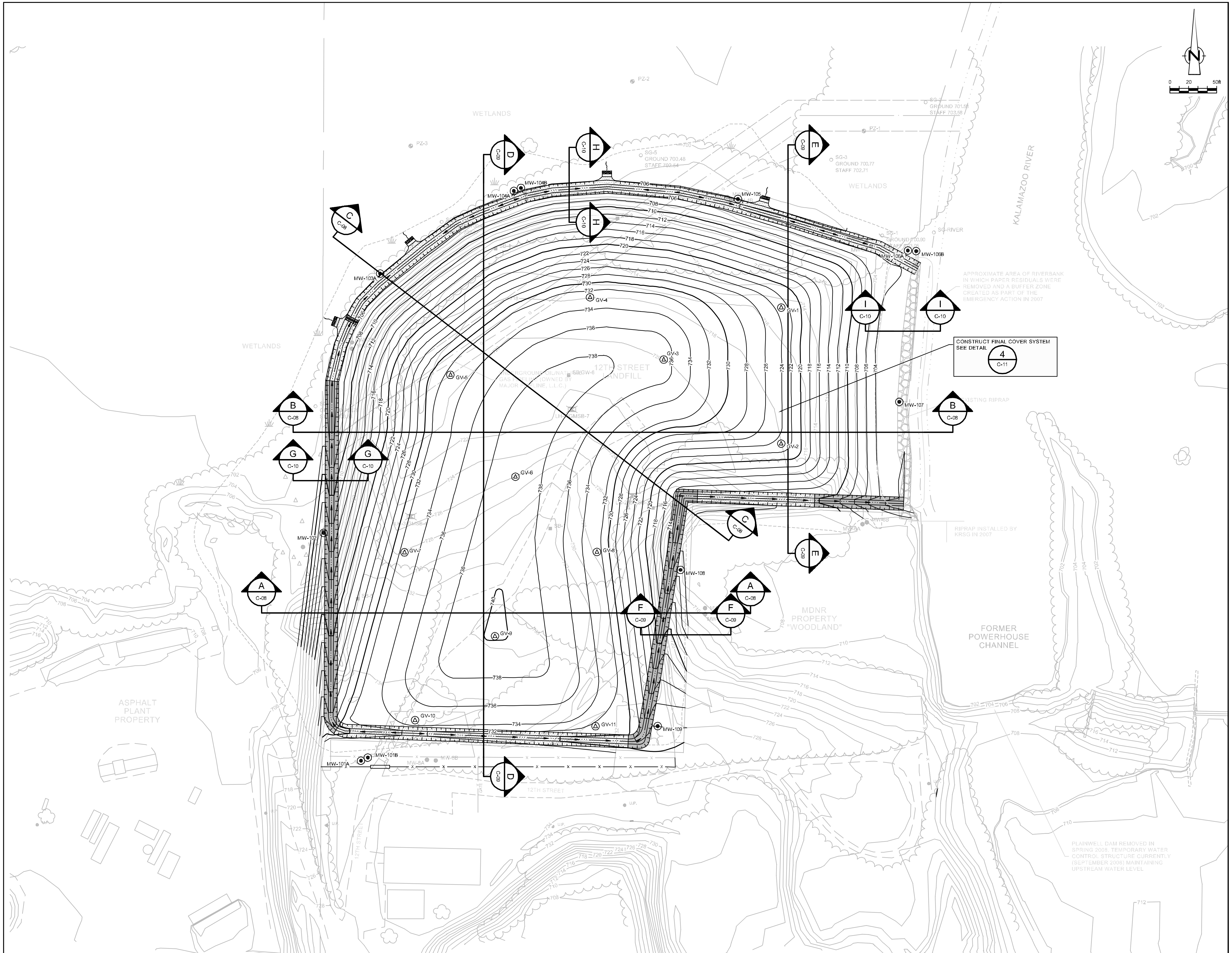


Nº	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
2	UPDATED FOR THIRD EPA SUBMISSION	OCT. 19, 2009	C.R.H.

LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING FENCE
- EXISTING BUILDING
- 700 EXISTING GROUND ELEVATION CONTOUR
- EXISTING TREES AND/OR BRUSH
- EXISTING WET AREA AND WETLAND
- EXISTING EDGE OF WATER
- EXISTING LIMITS OF PAPER RESIDUALS
- MW-1 EXISTING MONITORING WELL LOCATION (TO BE ABANDONED)
- PZ-2 EXISTING PIEZOMETER LOCATION (TO BE ABANDONED)
- LH-1/GMSB-7 EXISTING LEACHATE HEAD WELL LOCATION (TO BE ABANDONED)
- SG-1 EXISTING STAFF GAUGE (TO BE ABANDONED)
- SB-5 EXISTING INSPEC-SOL SOIL BORING LOCATION
- EXISTING VANE SHEAR TEST LOCATION
- 718 PROPOSED FINAL ELEVATION CONTOURS
- PROPOSED ROAD/DRAINAGE SWALE c/w TURF REINFORCEMENT MAT
- PROPOSED ROAD/DRAINAGE SWALE STABILIZED WITH GEOWEB
- PROPOSED GAS VENT
- MW-106B PROPOSED MONITORING WELL

NOTE:

1. ALL PROPOSED CONTOURS AND INVERT ELEVATIONS ARE TO BE CONFIRMED IN THE FIELD, PRIOR TO CONSTRUCTION, AND VERIFIED THAT THEY CONFORM WITH THE INTENT OF THE DESIGN.

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

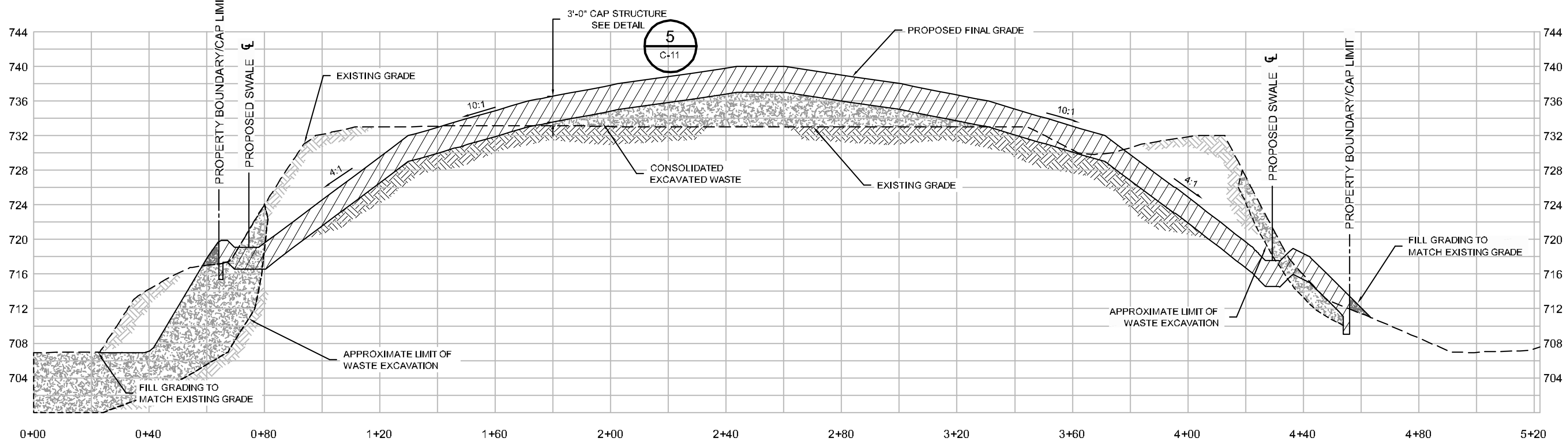
FINAL CONTOUR PLAN

CONESTOGA-ROVERS & ASSOCIATES

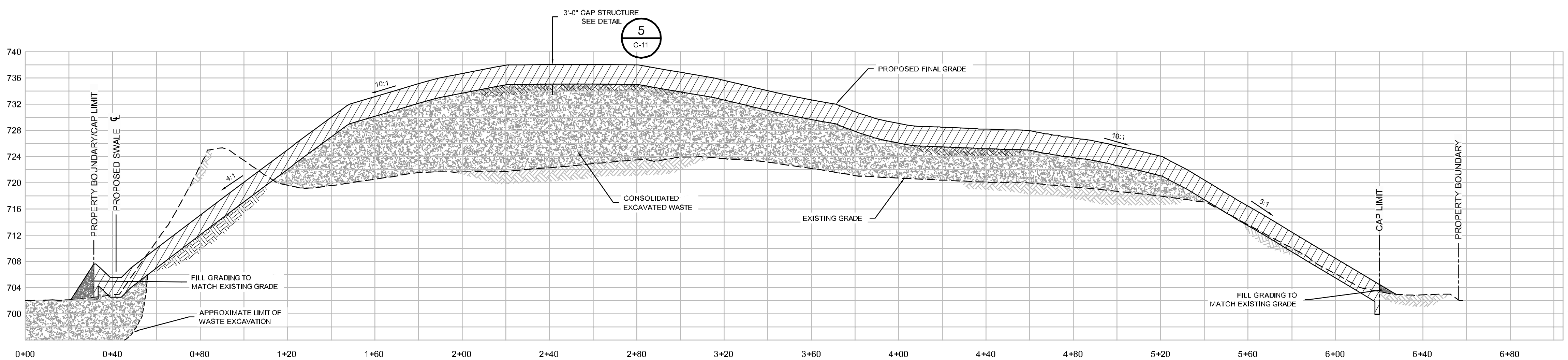
Source Reference: BASE ADAPTED FROM PREVIOUS RMT DESIGN

Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale: 1" = 50'-0"	Project Nº: 56393-05	Report Nº: 004	Drawing Nº: C-07

56393-05(004)CI-WA007 OCT 19/2009



SECTION A
HORZ: 1"=30'
VERT: 1"=10'
C-07



SECTION B
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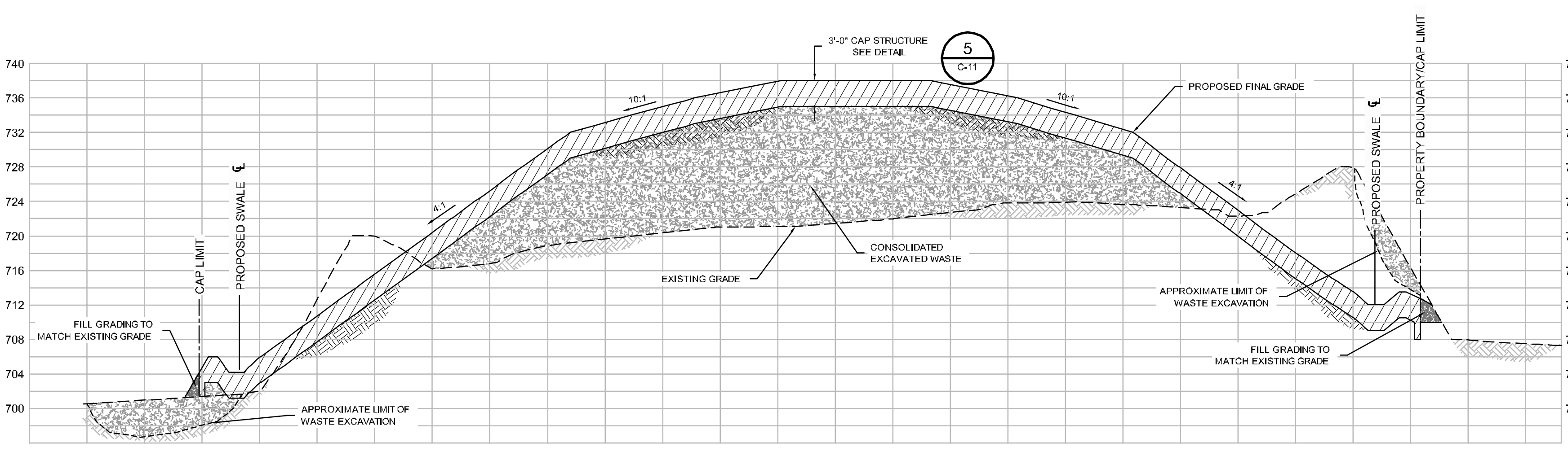
VERT: 1"=10'
C-07



SECTION C
HORZ: 1"=30'
VERT: 1"=10'
C-07

№	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
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12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

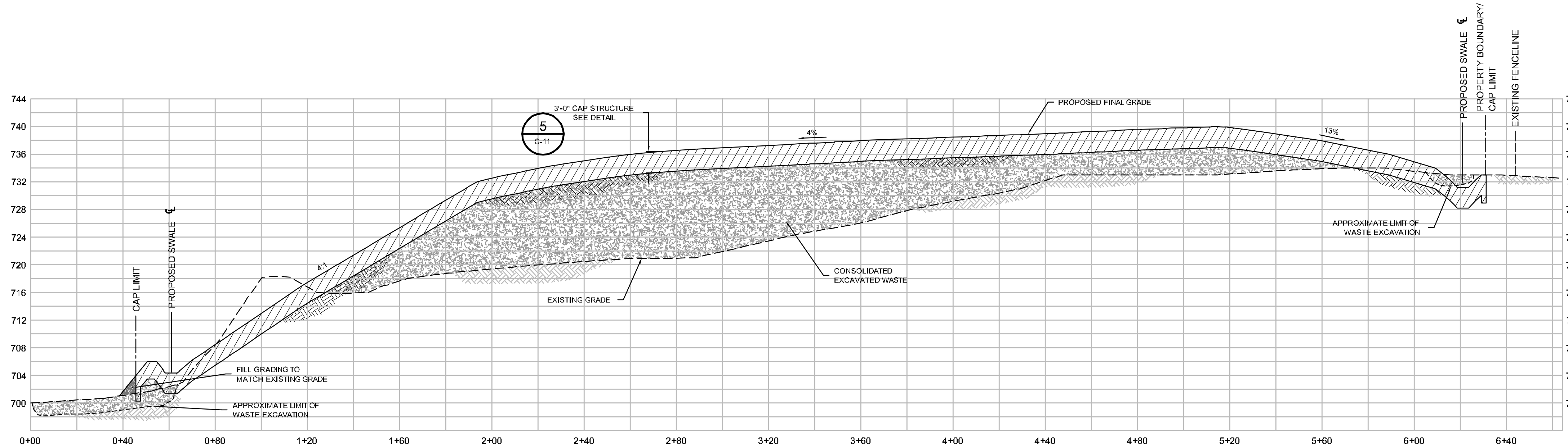
CROSS
SECTIONS I

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
BASE ADAPTED FROM PREVIOUS RMT DESIGN

Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale:	Project №:	Report №:	Drawing №:
AS SHOWN	56393-05	004	C-08

56393-05(004)CI-WA008 OCT 19/2009



SECTION D
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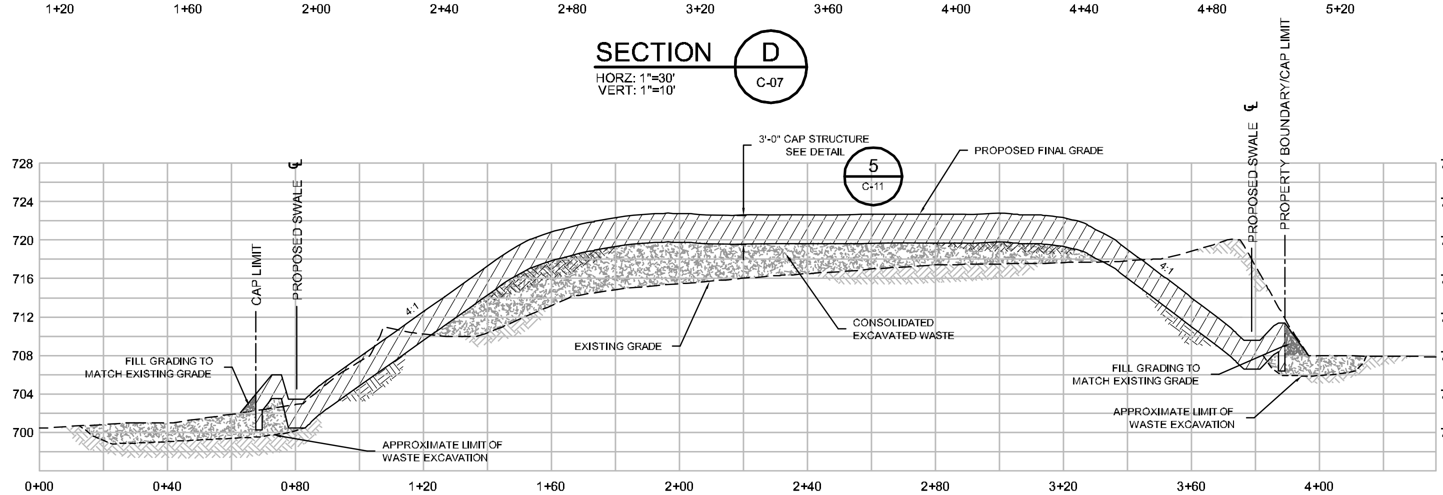
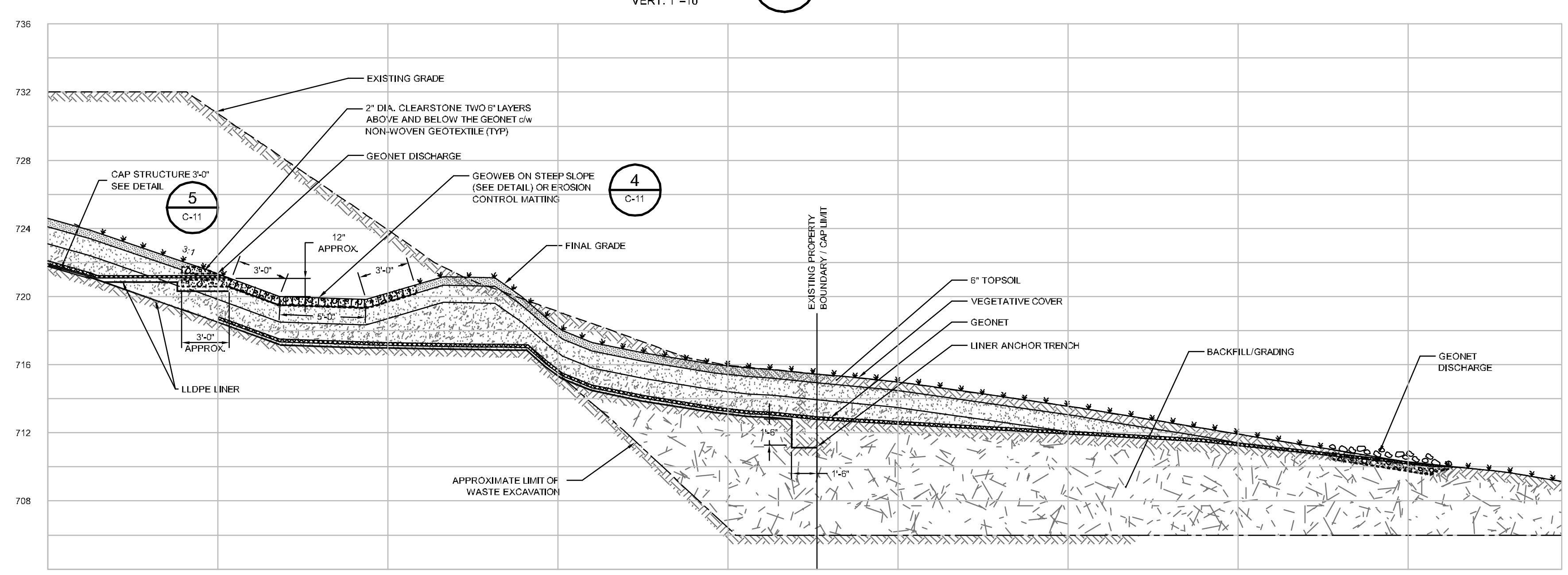
VERT: 1"=10'
C-07



SECTION E
HORZ: 1"=30'
VERT: 1"=10'
C-07



SECTION F
HORZ: 1" = 5'
VERT: 1" = 5'
C-07

№	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
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12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

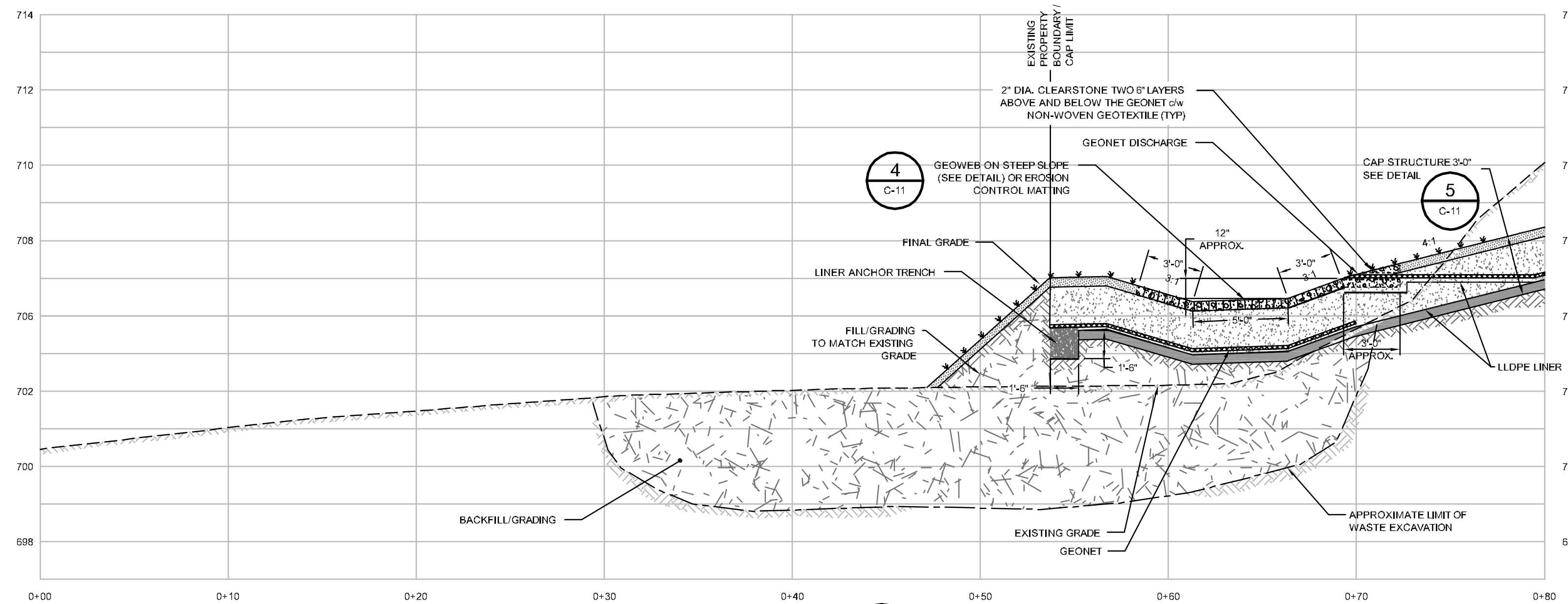
CROSS
SECTIONS II

CONESTOGA-ROVERS & ASSOCIATES

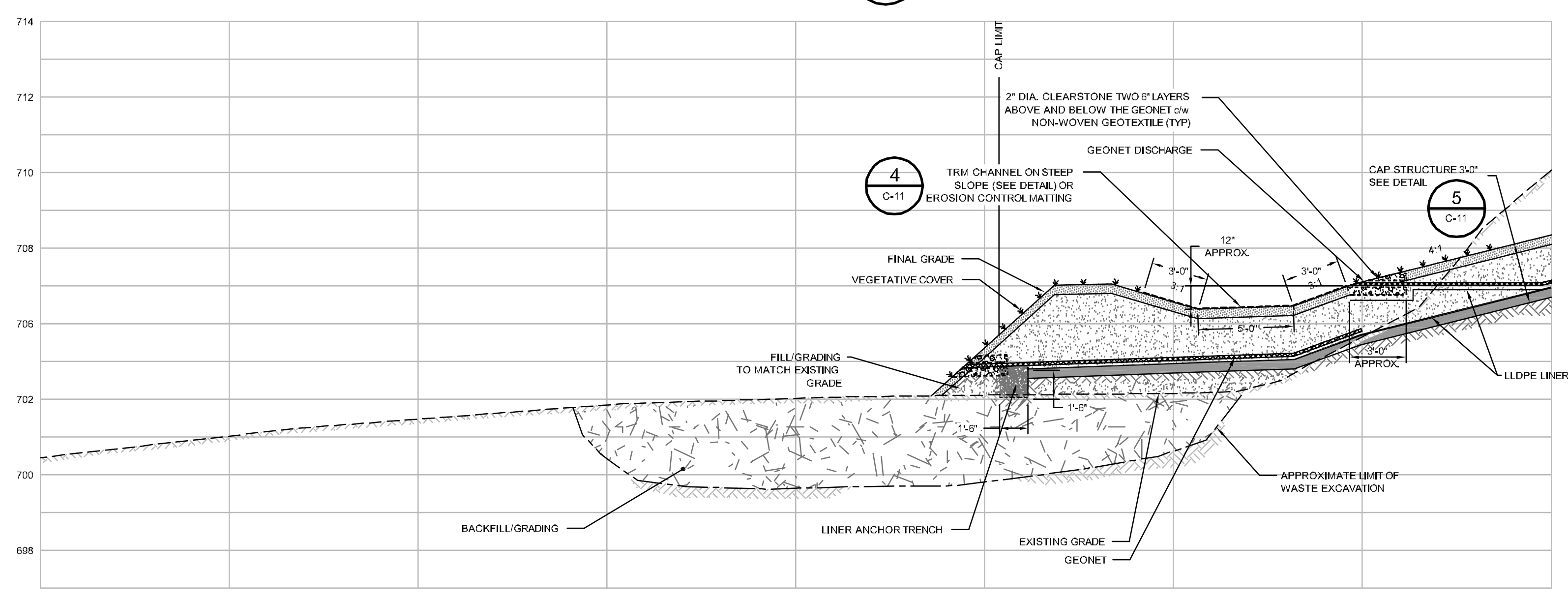
Source Reference:

Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale:	Project №:	Report №:	Drawing №:
AS SHOWN	56393-05	004	C-09

56393-05(004)CI-WA009 OCT 19/2009



SECTION G
C-07
HORZ: 1" = 5'
VERT: 1" = 5'



SECTION H
C-07
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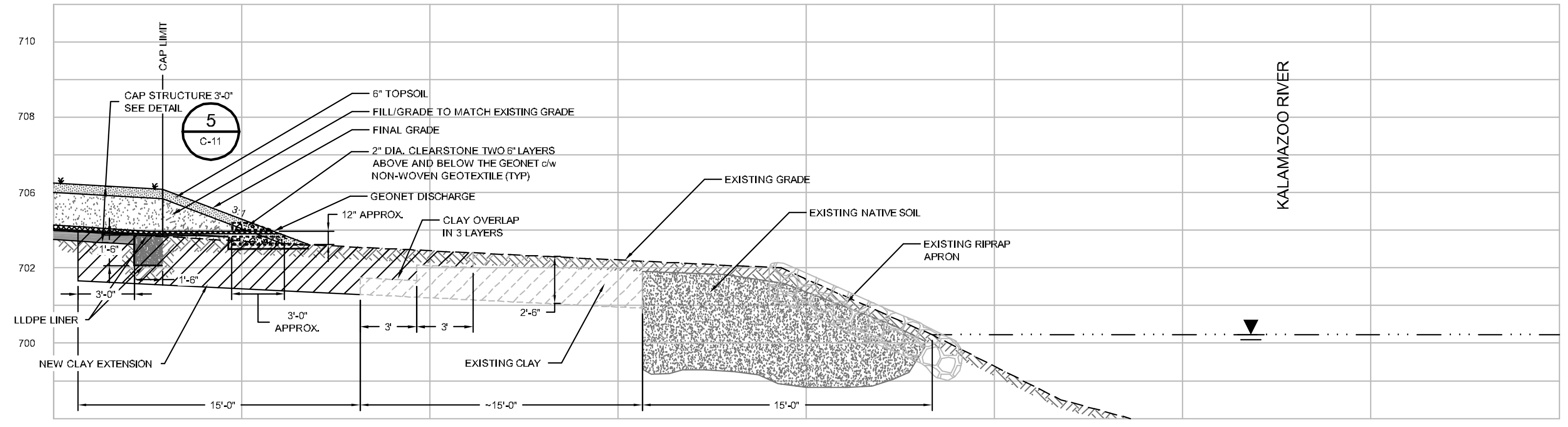
VERT: 1" = 5'



SECTION I
C-07
HORZ: 1" = 5'
VERT: 1" = 5'

№	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
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12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

CROSS
SECTIONS III

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale: AS SHOWN	Project №: 56393-05	Report №: 004	Drawing №: C-10

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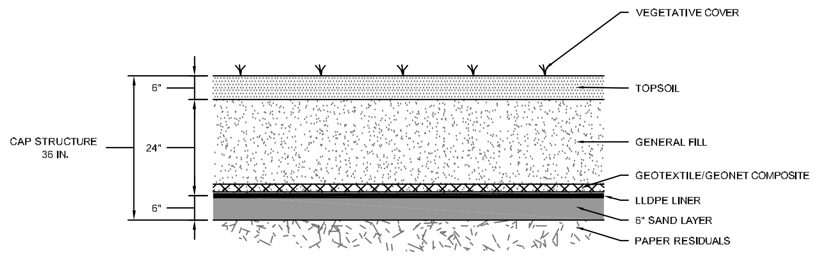
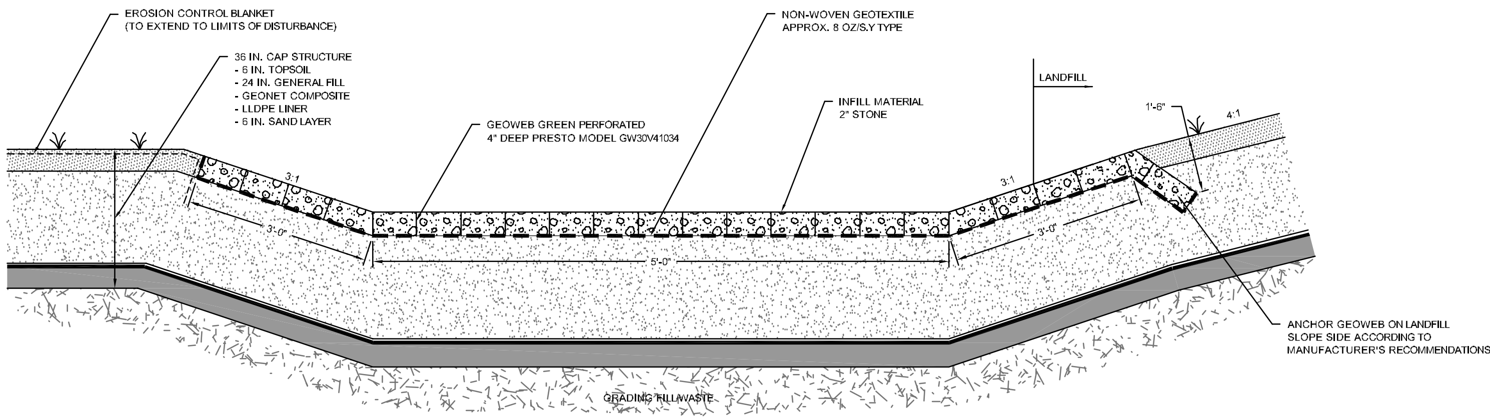
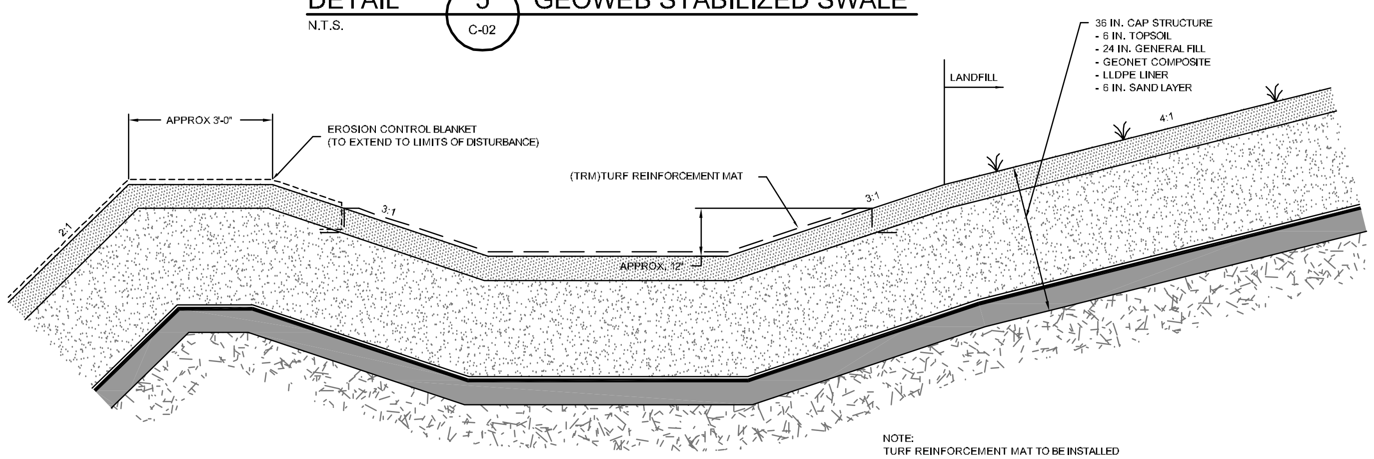


DETAIL 4 FINAL COVER SYSTEM
1" = 2'-0"
C-02, C-06, C-07

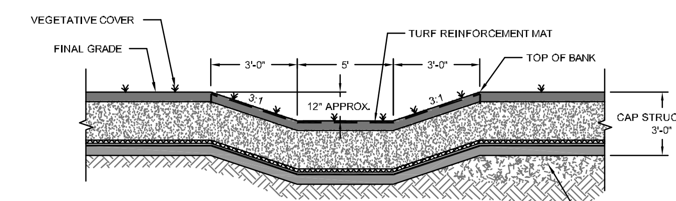


DETAIL 5 GEOWEB STABILIZED SWALE
N.T.S.
C-02

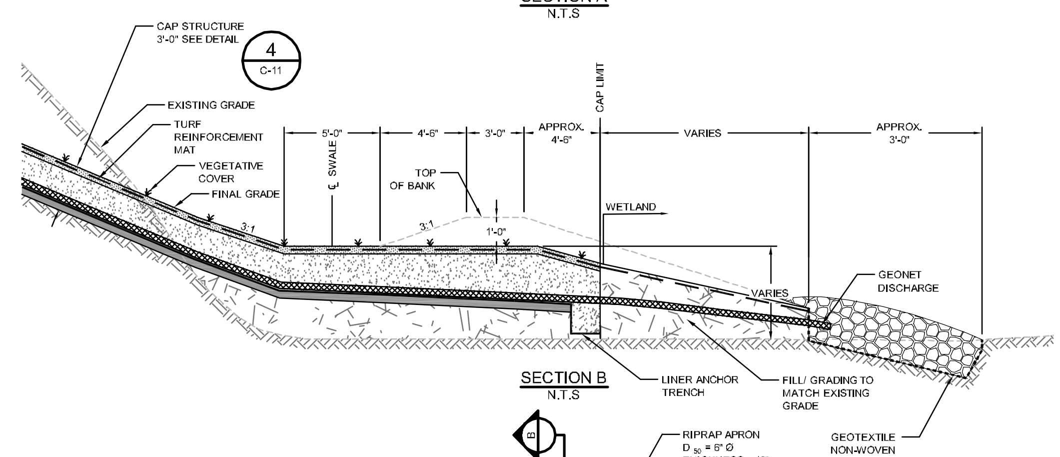


NOTE:
TURF REINFORCEMENT MAT TO BE INSTALLED AS PER MANUFACTURERS SPECIFICATIONS.

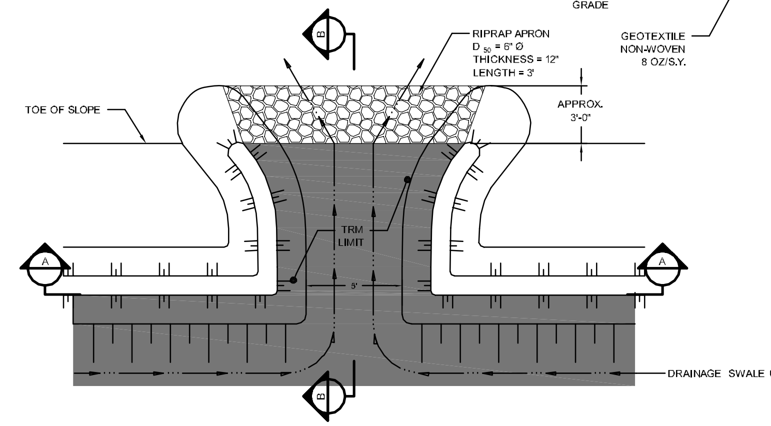
DETAIL 6 TURF REINFORCEMENT MAT STABILIZED SWALE
N.T.S.
C-02



SECTION A
N.T.S

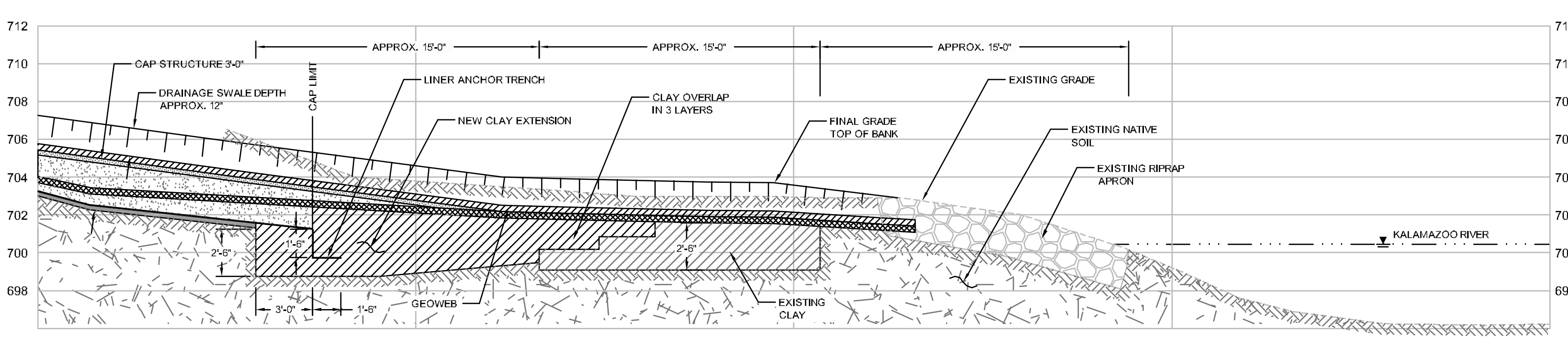


SECTION B
N.T.S



PLAN

DETAIL 8 OUTLET
N.T.S.
C-02



DETAIL 7 DRAINAGE SWALE TO KALAMAZOO RIVER DISCHARGE
1"=5'-0"
C-02

Nº	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
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12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

DETAILS I

CONESTOGA-ROVERS & ASSOCIATES

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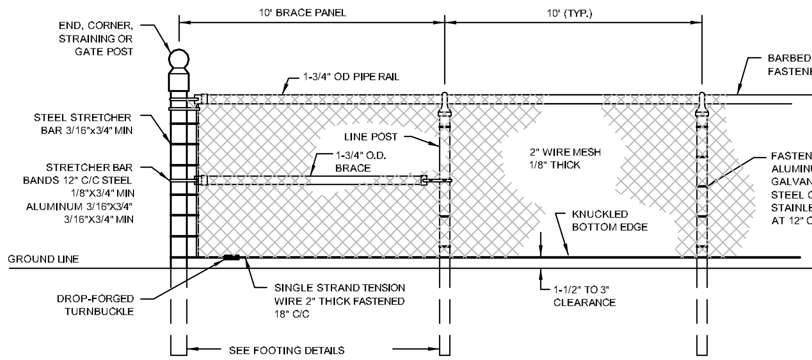
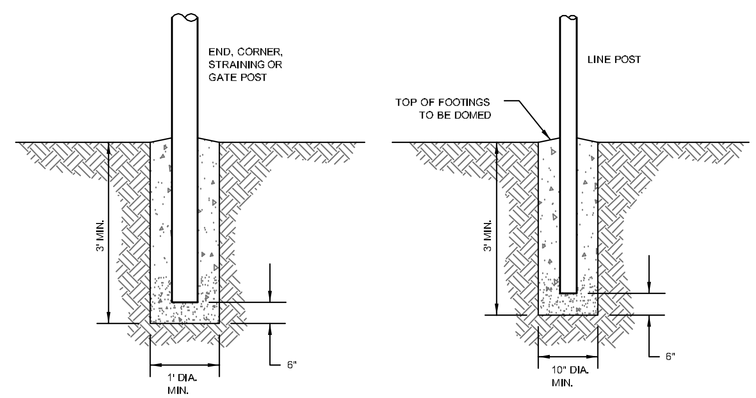
Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale:	Project Nº:	Report Nº:	Drawing Nº:
AS SHOWN	56393-05	004	C-11

56393-05(004)CI-WA010 OCT 19/2009



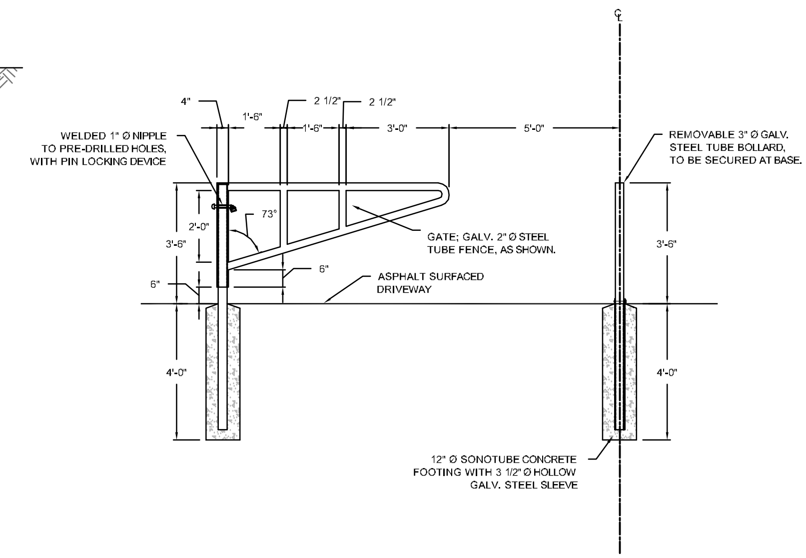
CORNER BRACE



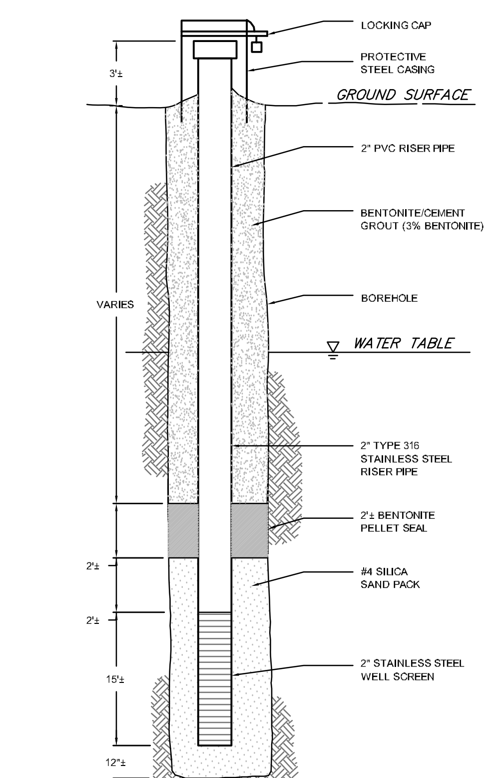
POST DETAILS

POST AND RAIL SIZES - FENCE			
USE	FABRIC HEIGHT	O.D. *	LBS/FT
INTERMEDIATE POSTS	BELOW 9'	2-3/8"	3.65
CORNER, END, GATE AND BRACE POSTS	BELOW 9'	2-7/8"	5.79
RAILS	ALL	1-5/8"	2.27
* CARBON STEEL PIPE - ASTM A-20, SCH 40			

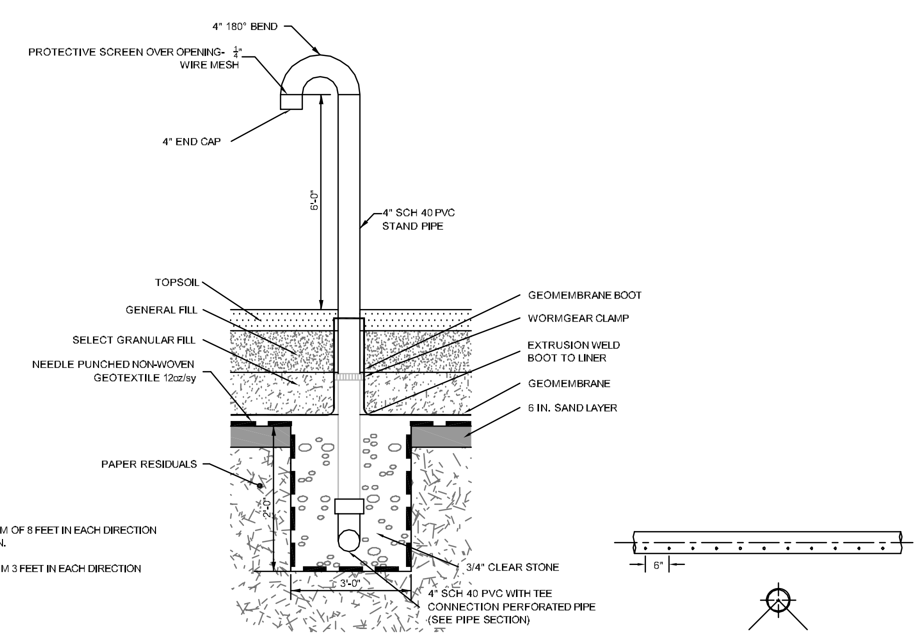
DETAIL 9 SITE FENCING
N.T.S. C-02



DETAIL 10 SWING GATE
N.T.S. C-02



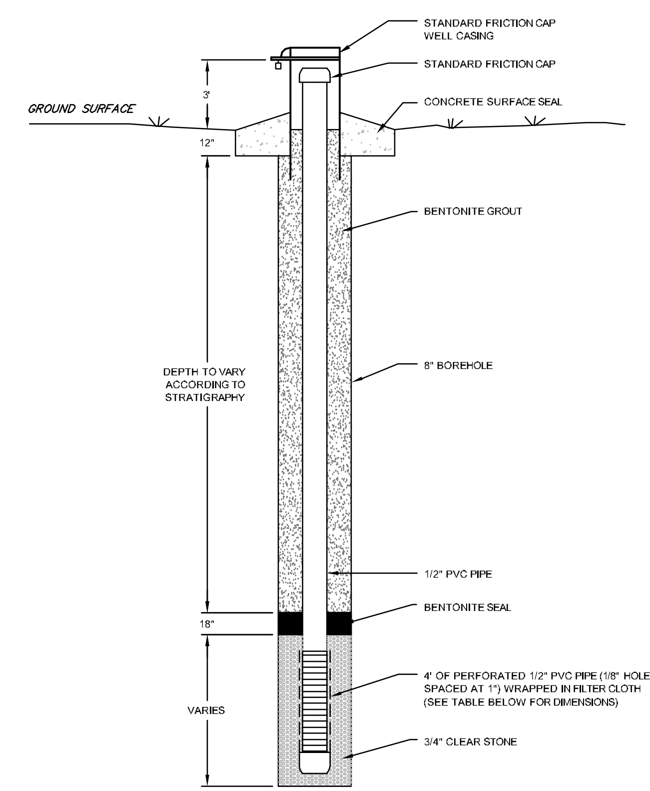
DETAIL 11 MONITORING WELL
N.T.S. C-02



NOTES:

1. PERFORATED PIPE TO EXTEND A MINIMUM OF 8 FEET IN EACH DIRECTION IN TRENCH FROM PASSIVE VENT LOCATION.
2. INSTALL GEOTEXTILE CUSHION A MINIMUM 3 FEET IN EACH DIRECTION PERPENDICULAR TO EDGE OF TRENCH.

DETAIL 12 GAS VENT
N.T.S. C-06



NOTE: GAS PROBE DEPTHS TO BE VERIFIED IN THE FIELD BASED ON LOCAL SOIL CONDITIONS

GAS PROBE	DEPTH (ft)	APPROXIMATE GW SURFACE ELEVATION	LENGTH OF SLOTTED PIPE (ft)
GP-1	10	708	5
GP-2	24	708	19
GP-3	10	700	5

DETAIL 13 GAS PROBE
N.T.S. C-06

Nº	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.
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SCALE VERIFICATION

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Approved

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Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

DETAILS II

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
G. CARLI	R. HOEKSTRA	JUNE 2009	
Scale: AS SHOWN	Project Nº: 56393-05	Report Nº: 004	Drawing Nº: C-12

56393-05(004)CI-WA010 OCT 19/2009

APPENDIX A

DOCUMENTATION OF THE PREDESIGN STUDIES

- Addition of landfill gas field testing data

CONESTOGA-ROVERS & ASSOCIATES
14496 Sheldon Road, Suite 200, Plymouth, MI
Telephone: (734) 453-5123 Fax: (734) 453-5201
www.CRAworld.com

TECHNICAL MEMORANDUM

TO:	Rick Hoekstra/Greg Carli	REF. NO.:	056393
FROM:	Douglas Gatrell/1/Det.	DATE:	June 11, 2009
RE:	**Landfill Gas Analysis and Design Layout** **12th Street Landfill, Otsego Township, Michigan**		

The purpose of this draft technical memorandum is to present the methodology for evaluating the landfill gas (LFG) potential and preliminary design components to be incorporated into the final cover design for the 12th Street Landfill (Site) located in Otsego Township, Michigan.

In order to complete the design of the LFG management component of the final landfill cover design, CRA performed the following activities:

- Reviewed existing modeling efforts for LFG generation;
- Determined the sensitivity of LFG generation model by varying the percentages of waste composition within the landfill;
- Conducted a modified Tier 3 analysis to determine the LFG production flow rate from the landfill along with a site-specific methane generation rate constant;
- Reviewed and summarized field data; and
- Evaluated the implementation of passive gas vent strips and a reduced quantity of gas vents (i.e., 1 per acre).

A. BACKGROUND INFORMATION

The Pre-Final Design Report prepared by RMT, dated January 2009, summarized the existing information regarding landfill gas in Section 3 and detailed the design components for the LFG system in Section 6 of this report. Attachment A presents the previous LFG generation modeling from this report.

The basis of the LFG collection design in the Pre-Final Design Report was based on information gathered as part of the pre-design studies conducted by RMT, information available from the King Highway Landfill, and experience with similar sites.

The following sections of this technical memorandum outline the methods used to obtain relevant data directly from the 12th Street Landfill and incorporated into the final LFG collection system design.

B. LANDFILL GAS MODELING

The previous modeling from the Pre-Final Design Report predicted a maximum LFG production rate of 278 cubic feet per minute (cfm) in year 1981. The model used paper products as the only waste disposed within the landfill along with a linear quantity of waste disposed per year between 1955 and 1981.

In revisiting the LFG model, CRA used the same linear waste quantity inputs from 1955 to 1981; however the waste characteristics were modified to reflect incremental decreases in the percentages of total paper products disposed and similar incremental increases in the percentages of construction debris components of waste within the landfill.

Attachment B presents CRA's LFG modeling sensitivity results. The modeling varied the quantity of degradable materials (paper products) by 15 and 25-percent, respectively. This resulted in the quantity of landfill gas decreasing to approximately 180 scfm and 160 scfm, respectively.

C. FIELD ACTIVITIES (MODIFIED TIER 3 TESTING)

The goal of the modified Tier 3 testing was to obtain direct information from the 12th Street Landfill to assist in the design of the passive gas collection system and to determine the LFG generation constant. These measures enabled for a site-specific design that should be cost-effective when compared to the general industry practices that do not incorporate results obtained from direct field measurements.

Modified Tier 3 Pre-Test Planning

Attachment C presents EPA's Method 2E. The field activities followed the established protocol for the testing procedure, with the following main deviations from the EPA's Method 2E being as follows:

- Due to the spacing of the existing wells, only single well testing was conducted. No multi-well testing was conducted.
- Field instrumentation was used to measure LFG composition and pressure. No laboratory analysis was performed.

Figure 1 presents the location of the gas extraction wells.

Modified Tier 3 Testing System

Testing wells were installed during the geotechnical investigation to the following specifications:

- Each LFG well borehole (12-inch diameter) was completed to the maximum depth of refuse. The wells were also installed above the leachate table.
- Each well casing was set at least 10 feet above the bottom of the boring due to the presence of leachate.
- Perforated piping comprised approximately two-thirds of each well casing length.
- Perforated piping was constructed from 6-inch polyvinyl chloride (PVC) piping with 1/2-inch diameter holes, four per circumference 90 degrees apart, with alternate rows staggered at 45 degrees.
- Gravel backfill (1 to 2-inch coarse gravel) was placed from the bottom of the borehole to 2 feet above the top of the screen interval.

- A minimum 1-foot thick bentonite seal was placed above the gravel.
- The top 3 feet of each well bore was sealed with bentonite amended soils (no less than 3:1 soil ratio of soil to bentonite).

The new LFG extraction wells were equipped with instrumentation to collect various flow and gas quality readings during the field activities. The instrumentation included:

- Built-in gas flow meter and quick-connect LFG sample port;
- Quick-connect impact pressure and static pressure ports; and
- Flow control gate valve.

LFG Blower Equipment

A LFG blower system consisting of a Regenair or EG&G Rotron centrifugal blower was utilized for the modified Tier 3 test, depending on the flow rate. The Regenair was used for flow rates less than 30 cfm and the EG&G Rotron was used for flow rates greater than 30 cfm. The piping from the well to the LFG blower included a length of 2-inch diameter PVC piping that was utilized for flow monitoring. A Magnehelic pressure gauge was installed in the extraction well riser pipe for measuring vacuum during the test. An additional monitoring port was installed for obtaining LFG quality readings. Additionally, valves and other appurtenances to control the LFG flow were included (see Figure 2 photo log of equipment).

Modified Tier 3 Test Plan

The modified Tier 3 extraction tests primary purpose was to establish an extractable quantity of LFG for each well and to determine the site-specific methane generation rate constant, k.

The LFG extraction test protocol involves slowly increasing the LFG flow rate from the tested well while measuring for breakthrough and monitoring to determine the pressure effects on nearby wells. The LFG flow rate was increased if the methane content within the LFG did not fall during the testing, and decreased if the methane content declined. This was done until a steady-state methane content was established. In addition to the criteria of steady-state methane content, the following additional protocols were used to stop the LFG extraction test:

1. Any time the oxygen content (three consecutive readings) in the extracted LFG exceeded 8 percent.
2. Any time the nitrogen content (three consecutive readings) in the extracted LFG exceeded 25 percent.
3. Any time the extracted LFG temperature at the wellhead (three consecutive readings) exceeded 140 degrees F.

Figure 3 presents the flow charts for the three phases of testing. The gas quality levels presented in Figure 3 will be evaluated and potentially revised based on field conditions.

D. MODIFICATIONS TO TEST PROTOCOL IN THE FIELD

The field procedures above were used for the LFG flow tests with the exceptions noted below:

1. The oxygen content was allowed to increase beyond 8 percent during the test.

2. The nitrogen content was allowed to increase beyond 25 percent during the test.
3. Temperature was not monitored during the testing.

These modifications were made based on the low flow and poor gas quality response from the landfill.

E. FIELD DATA

CRA mobilized to the Site on June 1, 2009 and began conducting the LFG field activities on June 2, 2009. CRA obtained pressure, gas quality, depth of extraction well, and depth to leachate readings prior to conducting the extraction test at each location. Table 1 present the results from these measurements.

GW-2

The extraction testing at gas well 2 (GW-2) resulted in the following:

- Methane content of the LFG gradually decreased from 18 percent to 9.3 percent.
- Carbon dioxide steadily decreased from 21.5 percent to 11.2 percent.
- Oxygen increased steadily from 5.8 percent to 11.6 percent.

The extraction test started at a flow rate of 30 scfm and an applied vacuum of 10 inches of water column (in WC). The testing was executed for three hours at these values. The flow rate and vacuum were adjusted to 15 cfm and an applied vacuum of 5 in. WC for an additional three hours of testing. The gas quality readings continued their respective trending during this time period. Figures 4 and 5 present the results from the field testing program for GW-2.

Pressure readings were observed to be zero at leachate well LH-2 during the LFG extraction test. This well is approximately 30 feet from GW-2.

GW-6

CRA attempted to conduct the LFG extraction testing at GW-6; however the leachate level was above the screened interval of the extraction well thereby not allowing LFG to pass. Figure 6 presents photographs of GW-6 with bubbles, presumably LFG, coming through the leachate.

CRA did attach the EG&G Rotron blower to the extraction well and induced a vacuum on the order of 40+ in. WC in an attempt to pull LFG through the water column. This resulted in the leachate column rising in GW-6 without releasing LFG. Figure 7 presents a photograph of the elevated leachate ring from the vacuum being applied to the extraction well.

F. DATA ASSESSMENT

The historic paper sludge waste placement coupled with a porous and sometimes non-existent soil cover and elevated leachate level result in a low LFG generation rate at this time. This is indicated in the LFG modeling; however the field activities reveal a lower than modeled LFG production rate. This is not unexpected, as there are several assumptions placed within the LFG model to generate the production curve. The field data is a direct extraction of information and is representative of actual conditions at the

12th Street Landfill. Lastly, the applied method is intended to be used for landfills containing municipal solid waste in an arid climate.

CRA estimated a radius of influence for GW-2 of 5 meters and calculated the volume of affected waste. The depth of waste affected by the extraction well was set at 10 meters such that it did not exceed the depth of the landfill per Method 2E. Thereafter, the methane generation potential (k) was determined from these field measurements and calculations. It should be noted that 30 cfm LFG extraction rate was used, without any reduction for extracting on a potential reservoir of LFG built up in the landfill due to a lack of any LFG extraction. A lower methane generation rate potential may result if a lower LFG flow representing a steady-state extraction rate is established, as opposed to the maximum that was used in the calculations. The calculated methane generation rate potential (k) was determined to be approximately 0.00002/year, which is considerably less than the EPA's default values of 0.02/year and 0.04/year depending on the precipitation rate. Tables 2 and 3 summarize the input data and flow rates used to calculate the methane generation rate, k.

The LFG quality was poor, as evidenced by the low methane and carbon dioxide content at the start of the extraction test, with the percentages of each continuing a downward trend the entire test. The downward trend continued even though the flow rate and applied vacuum was decreased on the first day of testing. The oxygen and balance gas percentages increased during the extraction test. In taking these quality factors into consideration, the extraction test removed an initial 'balloon' of methane within the landfill. The continued downward trend of LFG quality is indicative of the waste not being able to maintain production of methane at the rate it was being extracted. This is due to the age and quality of the waste, as well as the presence of an elevated leachate mound within the waste mass possibly preventing the production of methane. It should be noted that if the leachate mound were not present, the additional contribution of methane from the waste mass would be small due to the aforementioned reasons, and therefore, not alter the conclusions from the field investigation.

G. PASSIVE VENTING LAYER DESIGN

CRA has designed a passive gas venting system to manage the potential LFG buildup from beneath the geomembrane cover for the Site. The passive system consists of strips of a geosynthetic layer spaced approximately 200 feet across the slope of the landfill. The geosynthetic strips will be tied into a gravel pad at the crest of the slope with a vertical vent pipe installed through the liner cover system to discharge the LFG to the atmosphere.

CRA used a series of calculations to determine the LFG flux estimation and LFG transmissivity. The values were then used to determine the minimum characteristics to be used for the geosynthetic gas relief layer. These calculations are as follows:

$$\Phi_{LFG} = r_g * H_{avg\,waste} * \gamma_{waste} \quad \text{(LFG flux estimation)}$$

where

r_g	=	LFG generation rate
$H_{avg\,waste}$	=	average waste depth
γ_{waste}	=	unit weight of waste

$$\vartheta_{req\,LFG} = \frac{\Phi_{LFG} * \gamma_{LFG}}{u_{g\,max}} * \frac{L^2}{8} \text{ (Required LFG Relief Layer Transmissivity)}$$

where

$u_{g\,max}$	=	maximum LFG pressure
γ_{LFG}	=	unit weight of LFG
L	=	spacing between vent strips

$$\vartheta_{ultimate\,LFG} = \vartheta_{req\,LFG} * FS * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc} \text{ (Ultimate LFG Layer Transmissivity)}$$

where

FS	=	Factor of Safety
RF_{in}	=	intrusion reduction factor
RF_{cr}	=	creep reduction factor
RF_{cc}	=	chemical clogging reduction factor
RF_{bc}	=	biological clogging reduction factor

Once these factors have been calculated, the LFG transmissivity can be converted to a hydraulic transmissivity for the same drainage medium. This calculation is as follows:

$$\vartheta_{H20} = \frac{\mu_{LFG}}{\mu_{H20}} * \frac{\gamma_{H20}}{\gamma_{LFG}} * \vartheta_{ultimate\,LFG} \text{ (Hydraulic Transmissivity)}$$

where

μ_{LFG}	=	dynamic viscocity of LFG
μ_{H2O}	=	dynamic viscocity of water
γ_{LFG}	=	unit weight of LFG
γ_{H2O}	=	unit weight of water

Lastly, the validity of Darcy's law is conducted by calculating the Reynolds Number using the following equation:

$$R_e = \frac{vd}{\upsilon} \text{ (Reynolds Number)}$$

where

v	=	fluid velocity
d	=	characteristic flow dimension
υ	=	kinematic viscosity

The flow is laminar if the Reynolds Number is less than 2,000 for pipes. The Reynolds Number for one geosynthetic layer was reported to be about 500 (Richardson and Zhao, 2000).

Table 4 presents a summary of the above mentioned calculations using site-specific information. The design parameters selected were as follows:

- Flow rate of 30 cfm – value represents the upper bound of flow rate for the Site;
- Depth of waste of 30 feet – based on approximate information from geotechnical boreholes;
- Maximum uplift pressure of 15 in. WC – consistent with literature values; and
- Vent strip spacing of 200 feet – typical with industry standards.

The proposed passive gas venting system consists of the following:

- 200-foot vent strips spaced along the perimeter of the landfill, installed perpendicular to the slope from the toe of slope to the crown;
- perimeter toe strip to capture LFG that might develop at the base of the slope;
- 4-inch polyvinyl chloride (PVC) vent riser pipes at the crown of the slope for venting purposes; and
- vent strip connecting the risers at the crown of the slope as a redundant feature in case of localized failure.

This design incorporates site-specific information, an adequate factor of safety (FS=2.5) and reduction factors to account for various forms of potential flow irregularities, as well as best management practices for implementation of a LFG relief layer.

H. CONCLUSIONS

Implementation of the modified Tier 3 test proved that paper waste landfills have different LFG generation characteristics than the standard modeling values used by RMT. The revised modeling parameters collected during the testing program resulted in a more cost-effective gas collection and control system.

The 12th Street Landfill is generating volumes of LFG well below those predicted by LFG modeling. Implementation of field testing demonstrated that the landfill is not emitting methane at substantial quantities that require an extensive (active) gas collection system. The lower generation rates resulted in a gas collection system design that prevents any potential LFG build-up beneath the final cover without being too conservative in approach.

I. REFERENCES

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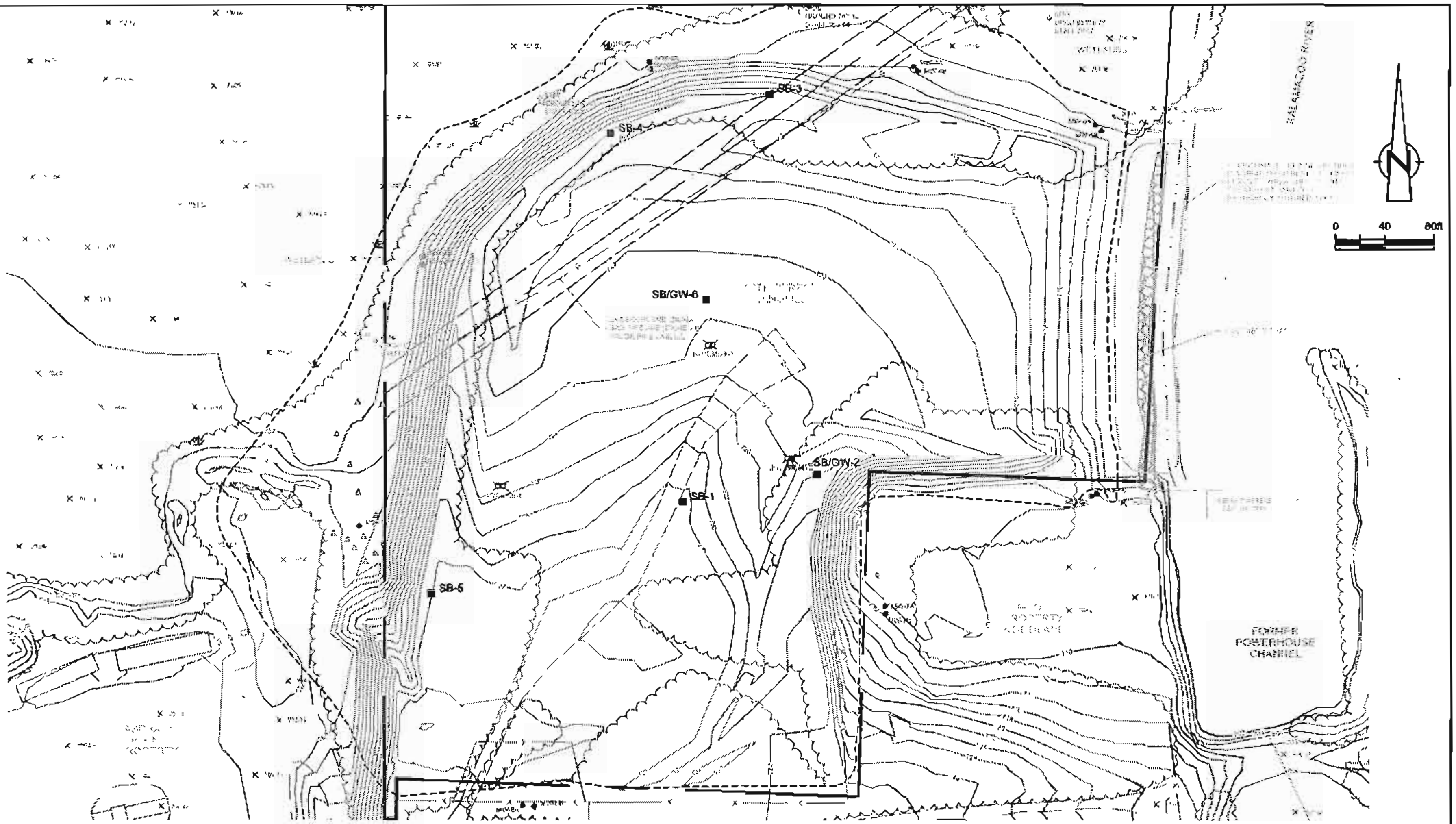
Richardson, G.N. and Zhao, A. (2000), "Gas Transmission in Geocomposite Systems", Geotechnical Fabrics Report, March, pp. 20-23, 2000.

Thiel, R.S. (1998), "Design Methodology for a Gas Pressure Relief Layer Below a Geomembrane Landfill Cover to Improve Slope Stability", Geosynthetic International, Vol. 5, No. 6 pp. 589-617.



LEGEND

APPROXIMATE PROPERTY BOUNDARY
700 EXISTING GROUND ELEVATION CONTOUR
EXISTING LIMITS OF PAPER RESIDUALS
■ SB-5 EXISTING INSPEC-SOL SOIL BORING LOCATION

figure 1

GAS EXTRACTION WELL LOCATIONS
12th STREET LANDFILL
Otsego Township, Michigan

056393-05(PRES001)GN-DE001 JUN 16/2009

Description: Blower data (high flow)
Date: 06/03/2009
Photographer: Douglas Gatrell

Description: Blower data (low flow)
Date: 06/03/2009
Photographer: Douglas Gatrell

056393

Figure 2
12th Street Landfill
Otsego, Michigan

Description: Flow meter data
Date: 06/03/2009
Photographer: Douglas Gatrell

Description: Pressure gauge
Date: 06/03/2009
Photographer: Douglas Gatrell

066393

Figure 2
12th Street Landfill
Otsego, Michigan

Description: Wellhead connection
Date: 06/03/2009
Photographer: Douglas Gatrell

Description: Gate valve and flow meter assembly
Date: 06/03/2009
Photographer: Douglas Gatrell

CRA

056393

Figure 2
12th Street Landfill
Otsego, Michigan

Description: Piping run
Date: 6/03/2009
Photographer: Douglas Gatrell

056393

Figure 2
12th Street Landfill
Otsego, Michigan

FIGURE 3 – FIELD TESTING PROTOCOL FLOWCHART, PHASE 1 (Initial Flow Rate = 30 cfm)

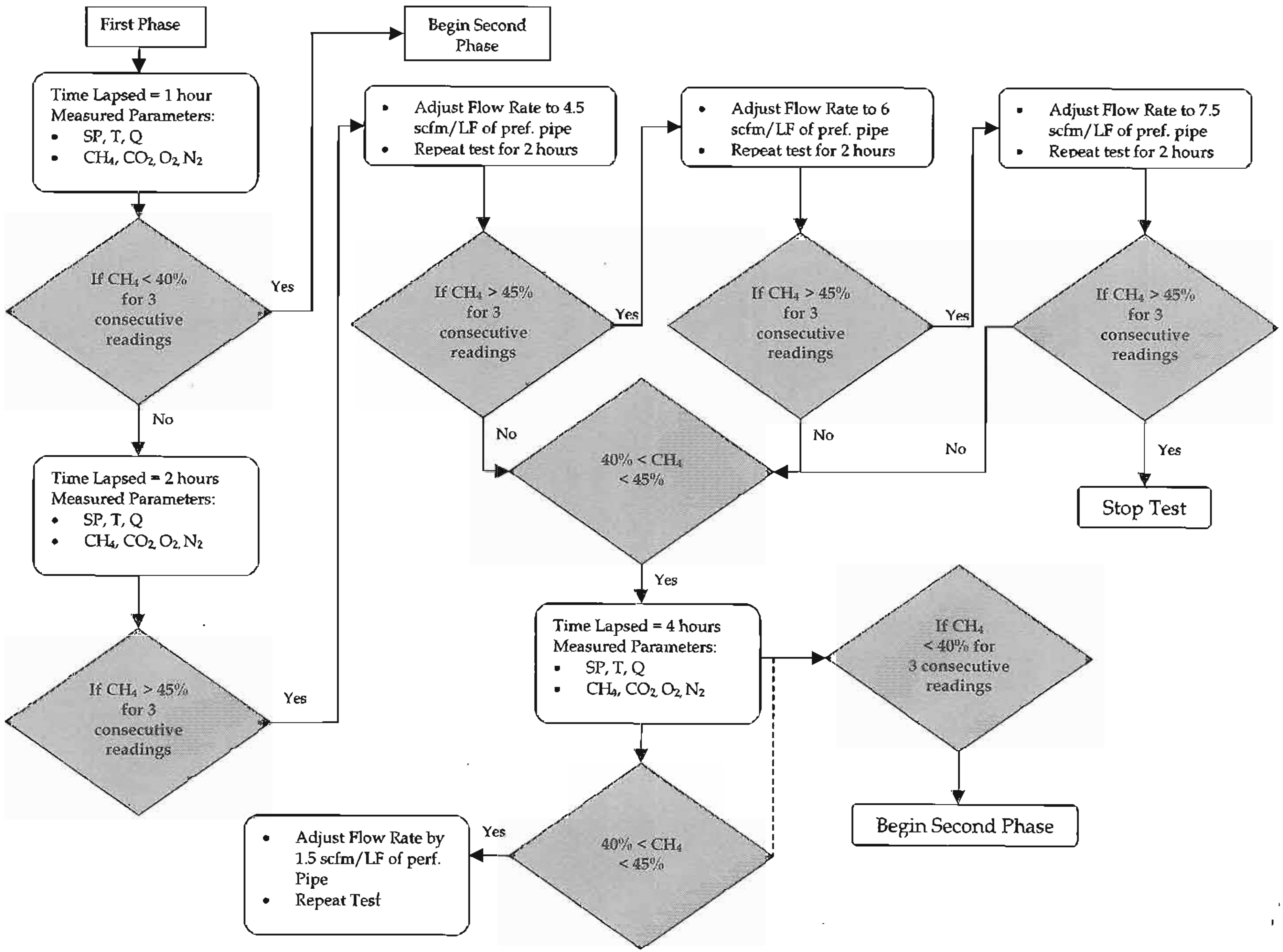


FIGURE 3 – FIELD TESTING PROTOCOL FLOWCHART, PHASE 2

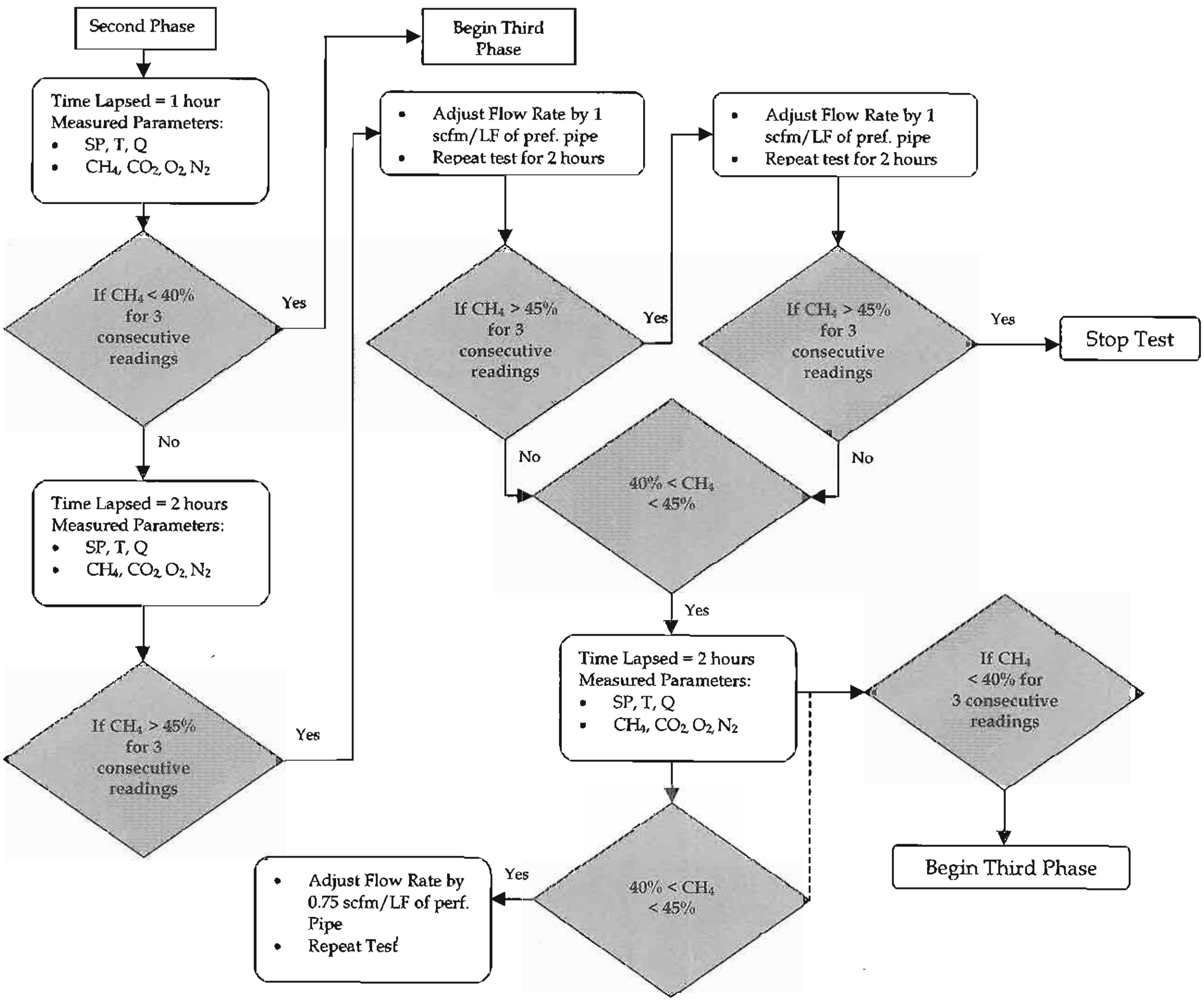


FIGURE 3 – FIELD TESTING PROTOCOL FLOWCHART, PHASE 3

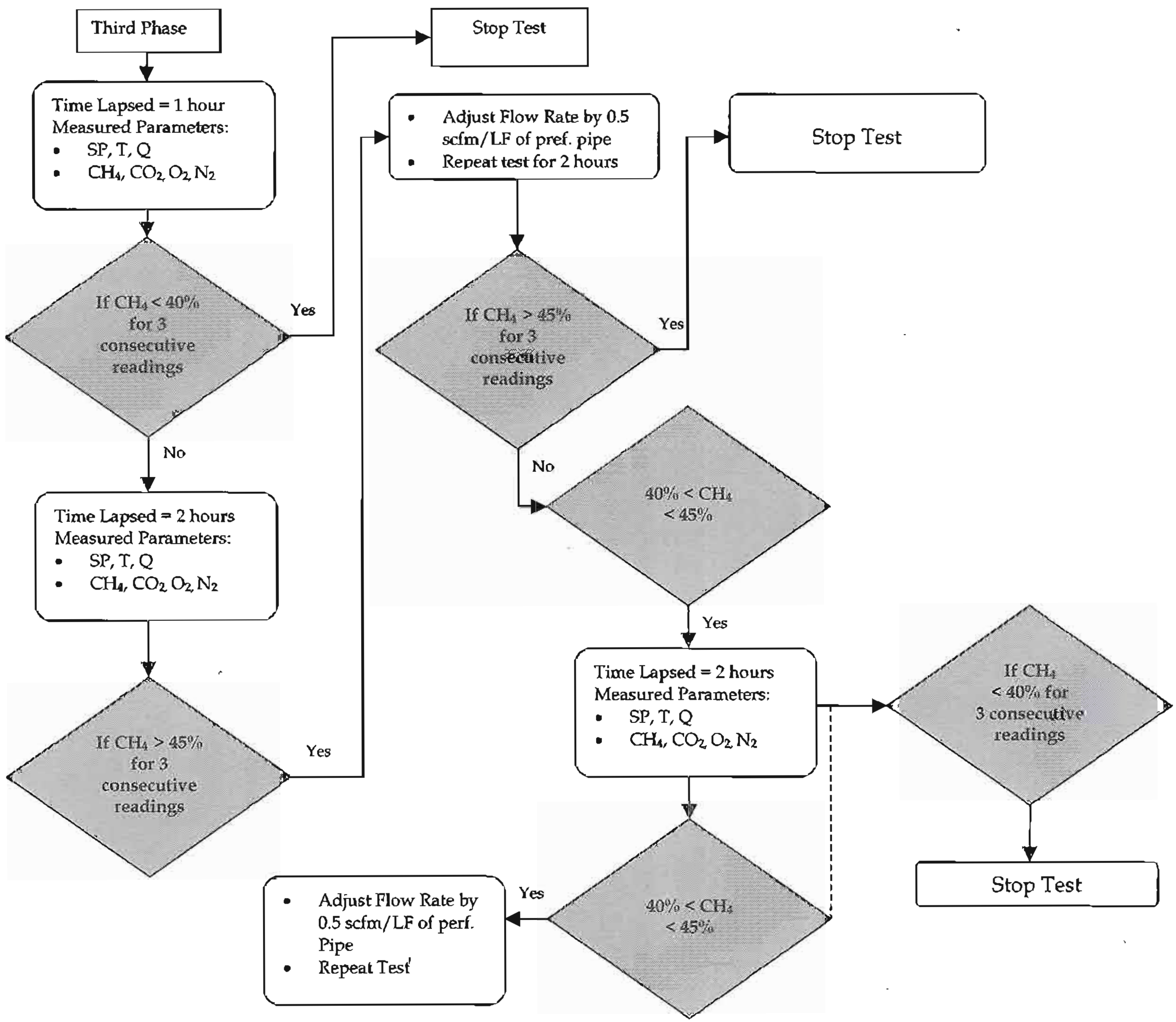


FIGURE 4

GW-2 EXTRACTION TEST RESULTS
FLOW RATE (Q=30 cfm and 15 cfm) AND GAS QUALITY READINGS
12TH STREET LANDFILL
OTSEGO, MICHIGAN

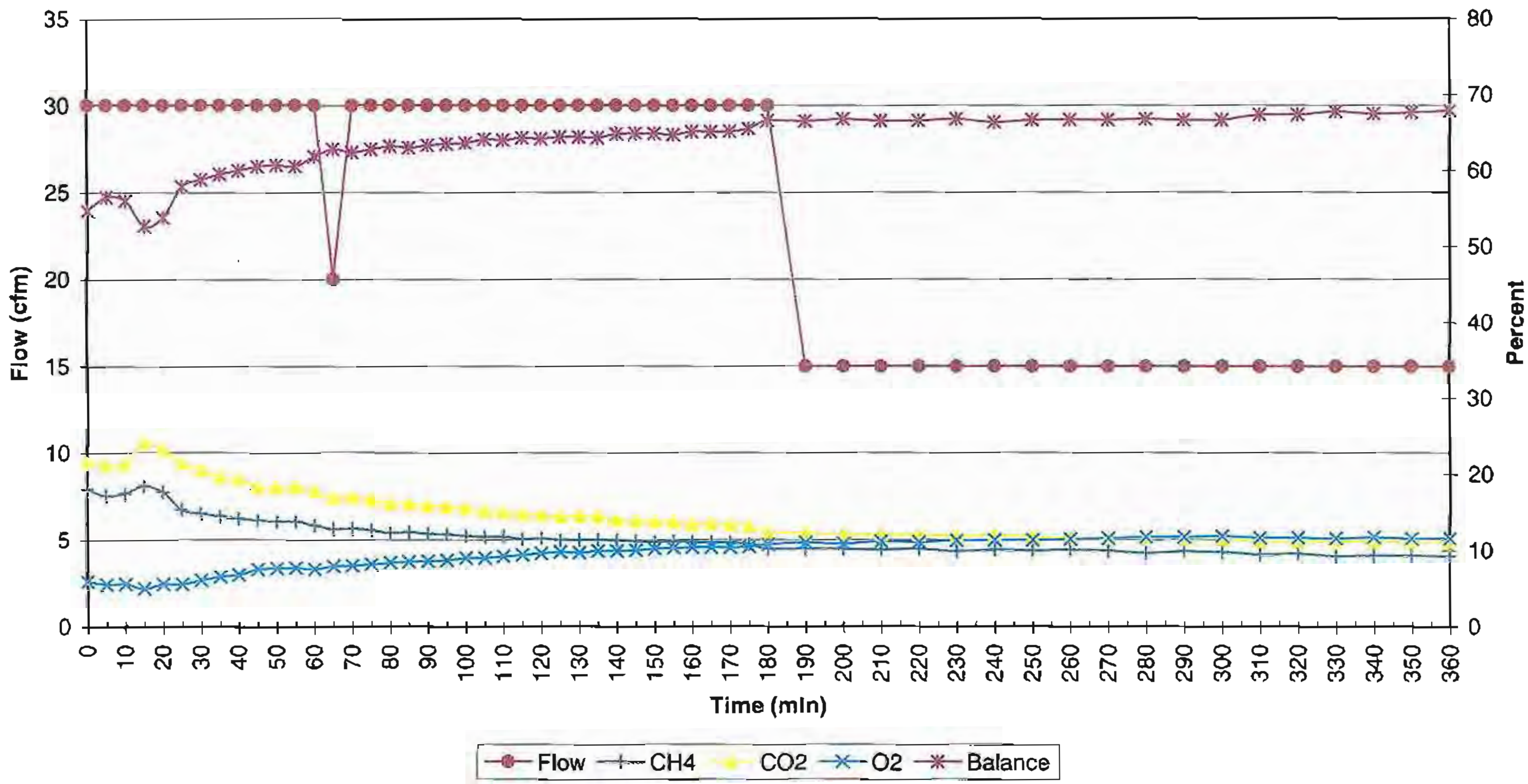
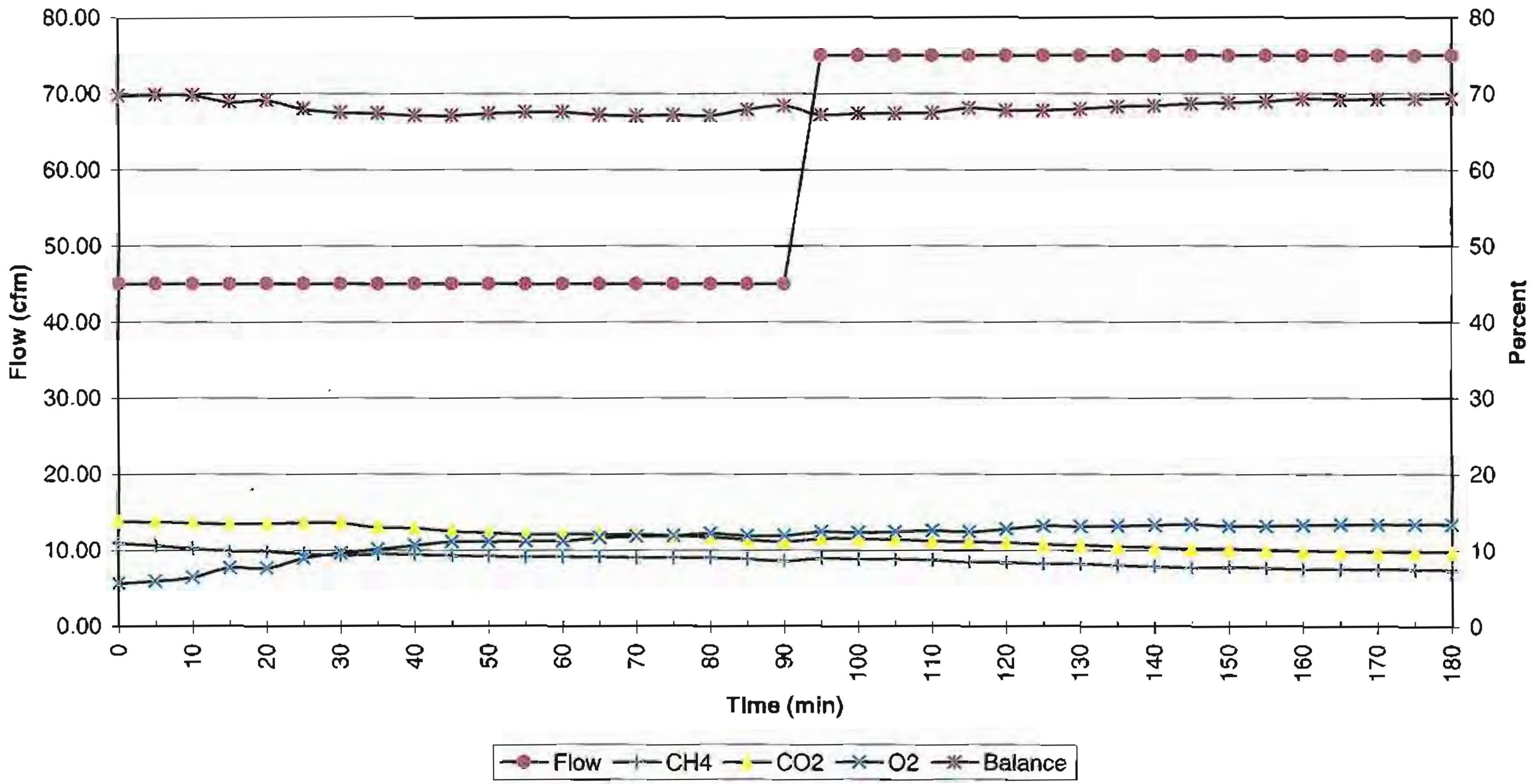


FIGURE 5

GW-2 EXTRACTION TEST RESULTS
FLOW RATE (Q=45 cfm and 75 cfm) AND GAS QUALITY READINGS
12TH STREET LANDFILL
OTSEGO, MICHIGAN



Description: GW-6 bubbles in leachate (1)
Date: 06/03/2009
Photographer: Douglas Gatrell

Description: GW-6 bubbles in leachate (2)
Date: 06/03/2009
Photographer: Douglas Gatrell

056393

Figure 6
12th Street Landfill
Otsego, Michigan

Description: GW-6 bubbles in leachate (3)
Date: 06/03/2009
Photographer: Douglas Gatrell

056393

Figure 6
12th Street Landfill
Otsego, Michigan

Description: GW-6 downhole after applied vacuum
Date: 06/03/2009
Photographer: Douglas Gatrell

056393

Figure 7
12th Street Landfill
Otsego, Michigan

TABLE 1
INITIAL FIELD MEASUREMENTS
12TH STREET LANDFILL
OTSEGO,MICHIGAN

Location	Elevation (AMSL)	DTW (ft)	DTW (AMSL)	DTB (ft)	DTB (AMSL)	Pressure (in. W.C.)	CH_4%	CO_2%	O_2%	Balance	H_2S (ppm)
GW-2	728.89	dry	--	28.50	700.39	0.00	1.1	0.7	18.5	79.7	--
GW-6	721.39	5.65	715.74	--	--	0.02	38.0	34.5	6.3	21.4	13.0
LH-1	--	5.00	--	--	--	--	0.9	0.4	19.5	79.1	0.0
LH-2	--	6.00	--	--	--	--	2.1	0.9	19.2	77.4	0.0

Notes:
AMSL - Above mean sea level
in. W. C. - inches of water column
ppm - parts per million
DTB - depth to bottom
DTW - depth to water
-- no data

TABLE 2

MODIFIED TIER 3 ANALYSIS
(FLOW = 30 CFM AND 15 CFM)
12TH STREET LANDFILL
OTSEGO, MICHIGAN

Aavg =	40 yrs
Waste Density =	60 lbs/cf
Waste Density =	1.17 Mg/m3
Well Depth (WD) =	7.5 m
Rma =	5 m
Lo =	100 m3/Mg
f =	0.75

Site: 12th Street Landfill
Proj. No: 056393
Sample Location: GW-2
Date: 6/2/2009

															Landfill Gas Generation Constant Calculation		Landfill Gas Quality Readings				Pressure Readings	
Clock Time	Time (min)	Blower Vacuum (in WC)	LFG Flow Rate (Qi) (scfm)	LFG Flow Rate (Qi) (m3/min)	Stabilized Flow Rate (Qf) (m3/min)	Radius of Influence (Rsa) (m)	Depth Affected by Extraction Well (Dst) (m)	Extraction Well Void Volume (Vv) (m3)	Time of the ith Interval (tvi) (hr)	Total Volume of LFG Extracted from Well (Vl) (Vl >= 2 Vv) (m3)	Depth Affected by Extraction Well (D) (m)	Volume of Refuse Affected by Test Well (Vr) (m3)	Mass Affected by Test Well (Mr) (Mg)	Modified Methane Generation Potential (Lo') (m3/Mg)	Assumed k (1/yr)	Resultant (= 0.7)	Methane (%)	Carbon Dioxide (%)	Oxygen (%)	Balance (%)	LH-1 (in WC)	LH-2 (in WC)
10:10	0.00	10	30	0.85	0.85	5.00	12.50	125.00	0.000	0.00	10.00	250.00	214.10	75.00	1.000E+00	14.7152	18	21.5	5.8	54.7	NA	0
	5.00	10	30	0.85	0.85	5.00	12.50	125.00	0.083	254.89	10.00	250.00	214.10	75.00	9.000E-01	14.6365	17.1	21	5.4	56.5	NA	0
	10.00	10	30	0.85	0.85	5.00	12.50	125.00	0.167	509.77	10.00	250.00	214.10	75.00	8.000E-01	14.3785	17.4	21.1	5.5	56	NA	0
	15.00	10	30	0.85	0.85	5.00	12.50	125.00	0.250	764.66	10.00	250.00	214.10	75.00	7.000E-01	13.9044	18.4	24	4.9	52.7	NA	0
	20.00	10	30	0.85	0.85	5.00	12.50	125.00	0.333	1,019.54	10.00	250.00	214.10	75.00	6.000E-01	13.1715	17.6	23.1	5.5	53.8	NA	0
	25.00	10	30	0.85	0.85	5.00	12.50	125.00	0.417	1,274.43	10.00	250.00	214.10	75.00	5.000E-01	12.1306	15.3	21.3	5.5	57.9	NA	0
10:40	30.00	10	30	0.85	0.85	5.00	12.50	125.00	0.500	1,529.31	10.00	250.00	214.10	75.00	4.000E-01	10.7251	14.8	20.4	6	58.8	NA	0
	35.00	10	30	0.85	0.85	5.00	12.50	125.00	0.583	1,784.20	10.00	250.00	214.10	75.00	3.000E-01	8.8898	14.5	19.5	6.5	59.5	NA	0
	40.00	10	30	0.85	0.85	5.00	12.50	125.00	0.667	2,039.08	10.00	250.00	214.10	75.00	2.000E-01	6.5498	14.1	19.2	6.7	60	NA	0
	45.00	10	30	0.85	0.85	5.00	12.50	125.00	0.750	2,293.97	10.00	250.00	214.10	75.00	1.000E-01	3.6193	13.9	18.2	7.4	60.5	NA	0
	50.00	10	30	0.85	0.85	5.00	12.50	125.00	0.833	2,548.85	10.00	250.00	214.10	75.00	9.000E-02	3.2901	13.7	18.1	7.5	60.7	NA	0
	55.00	10	30	0.85	0.85	5.00	12.50	125.00	0.917	2,803.74	10.00	250.00	214.10	75.00	8.000E-02	2.9539	13.7	18.2	7.6	60.5	NA	0
11:10	60.00	10	30	0.85	0.85	5.00	12.50	125.00	1.000	3,058.62	10.00	250.00	214.10	75.00	7.000E-02	2.6107	13.2	17.6	7.4	61.8	NA	0
	65.00	5	20	0.57	0.57	5.00	12.50	125.00	1.083	3,228.55	10.00	250.00	214.10	75.00	6.000E-02	2.2602	12.7	16.7	7.8	62.8	NA	0
	70.00	10	30	0.85	0.85	5.00	12.50	125.00	1.167	3,483.43	10.00	250.00	214.10	75.00	5.000E-02	1.9024	12.8	16.9	7.9	62.4	NA	0
	75.00	10	30	0.85	0.85	5.00	12.50	125.00	1.250	3,738.32	10.00	250.00	214.10	75.00	4.000E-02	1.5372	12.8	16.5	8.1	62.8	NA	0
	80.00	10	30	0.85	0.85	5.00	12.50	125.00	1.333	3,993.20	10.00	250.00	214.10	75.00	3.000E-02	1.1645	12.3	16.1	8.4	63.2	NA	0
	85.00	10	30	0.85	0.85	5.00	12.50	125.00	1.417	4,248.09	10.00	250.00	214.10	75.00	2.000E-02	0.7841	12.4	16.1	8.5	63	NA	0
11:40	90.00	10	30	0.85	0.85	5.00	12.50	125.00	1.500	4,502.97	10.00	250.00	214.10	75.00	1.000E-02	0.3960	12.2	15.9	8.8	63.3	NA	0
	95.00	10	30	0.85	0.85	5.00	12.50	125.00	1.583	4,757.86	10.00	250.00	214.10	75.00	9.000E-03	0.3567	12.1	15.7	8.7	63.5	NA	0
	100.00	10	30	0.85	0.85	5.00	12.50	125.00	1.667	5,012.74	10.00	250.00	214.10	75.00	8.000E-03	0.3174	11.9	15.5	9	63.6	NA	0
	105.00	10	30	0.85	0.85	5.00	12.50	125.00	1.750	5,267.63	10.00	250.00	214.10	75.00	7.000E-03	0.2780	11.8	15.1	9	64.1	NA	0
	110.00	10	30	0.85	0.85	5.00	12.50	125.00	1.833	5,522.51	10.00	250.00	214.10	75.00	6.000E-03	0.2385	11.8	15	9.2	64	NA	0
	115.00	10	30	0.85	0.85	5.00	12.50	125.00	1.917	5,777.40	10.00	250.00	214.10	75.00	5.000E-03	0.1990	11.5	14.8	9.4	64.3	NA	0
12:10	120.00	10	30	0.85	0.85	5.00	12.50	125.00	2.000	6,032.29	10.00	250.00	214.10	75.00	4.000E-03	0.1593	11.6	14.6	9.6	64.2	NA	0
	125.00	10	30	0.85	0.85	5.00	12.50	125.00	2.083	6,287.17	10.00	250.00	214.10	75.00	3.000E-03	0.1196	11.4	14.4	9.8	64.4	NA	0
	130.00	10	30	0.85	0.85	5.00	12.50	125.00	2.167	6,542.06	10.00	250.00	214.10	75.00	2.000E-03	0.0798	11.4	14.5	9.7	64.4	NA	0
	135.00	10	30	0.85	0.85	5.00	12.50	125.00	2.250	6,796.94	10.00	250.00	214.10	75.00	1.000E-03	0.0399	11.4	14.4	9.9	64.3	NA	0
	140.00	10	30	0.85	0.85	5.00	12.50	125.00	2.333	7,051.83	10.00	250.00	214.10	75.00	9.000E-04	0.0359	11.3	14	9.9	64.8	NA	0
	145.00	10	30	0.85	0.85	5.00	12.50	125.00	2.417	7,306.71	10.00	250.00	214.10	75.00	8.000E-04	0.0319	11.2	13.9	10	64.9	NA	0
12:40	150.00	10	30	0.85	0.85	5.00	12.50	125.00	2.500	7,561.60	10.00	250.00	214.10	75.00	7.000E-04	0.0280	11.1	13.8	10.2	64.9	NA	0
	155.00	10	30	0.85	0.85	5.00	12.50	125.00	2.583	7,816.48	10.00	250.00	214.10	75.00	6.000E-04	0.0240	11.2	13.8	10.3	64.7	NA	0
	160.00	10	30	0.85	0.85	5.00	12.50	125.00	2.667	8,071.37	10.00	250.00	214.10	75.00	5.000E-04	0.0200	11.1	13.4	10.4	65.1	NA	0
	165.00	10	30	0.85	0.85	5.00	12.50	125.00	2.750	8,326.25	10.00	250.00	214.10	75.00	4.000E-04	0.0160	11	13.5	10.4	65.1	NA	0
	170.00	10	30	0.85	0.85	5.00	12.50	125.00	2.833	8,581.14	10.00	250.00	214.10	75.00	3.000E-04	0.0120	11	13.4	10.4	65.2	NA	0
	175.00	10	30	0.85	0.85	5.00	12.50	125.00	2.917	8,836.02	10.00	250.00	214.10	75.00	2.000E-04	0.0080	10.8	13.2	10.5	65.5	NA	0
13:10	180.00	10	30	0.85	0.85	5.00	12.50	125.00	3.000	9,090.91	10.00	250.00	214.10	75.00	1.000E-04	0.0040	10.2	12.4	10.8	66.6	NA	0
	190.00	5	15	0.42	0.42	5.00	12.50	125.00	3.167	9,345.79	10.00	250.00	214.10	75.00	9.000E-05	0.0036	10.2	12.3	11	66.5	NA	0
	200.00	5	15	0.42	0.42	5.00	12.50	125.00	3.333	9,600.68	10.00	250.00	214.10	75.00	8.000E-05	0.0032	10.2	12.1	10.9	66.8	NA	0
13:40	210.00	5	15	0.42	0.42	5.00	12.50	125.00	3.500	9,855.56	10.00	250.00	214.10	75.00	7.000E-05	0.0028	10.1	12.1	11.2	66.6	NA	0
	220.00	5	15	0.42	0.42	5.00	12.50	125.00	3.667	10,110.45	10.00	250.00	214.10	75.00	6.000E-05	0.0024	10.2	12.1	11.1	66.6	NA	0
	230.00	5	15	0.42	0.42	5.00	12.50	125.00	3.833	10,365.34	10.00	250.00	214.10	75.00	5.000E-05	0.0020	9.9	12	11.3	66.8	NA	0
14:10	240.00	5	15	0.42	0.42	5.00	12.50	125.00	4.000	10,620.22	10.00	250.00	214.10	75.00	4.000E-05	0.0016	10.1	12.1	11.4	66.4	NA	0
	250.00	5	15	0.42	0.42	5.00	12.50	125.00	4.167	10,875.11	10.00	250.00	214.10	75.00	3.000E-05	0.0012	10	11.9	11.4	66.7	NA	0
	260.00	5	15	0.42	0.42	5.00	12.50	125.00	4.333	11,129.99	10.00	250.00	214.10	75.00	2.000E-05	0.0008	10.1	11.7	11.5	66.7	NA	0
14:40	270.00	5	15	0.42	0.42	5.00	12.50	125.00	4.500	11,384.88	10.00	250.00	214.10	75.00	1.000E-05	0.0004	10	11.7	11.6	66.7	NA	0
	280.00	5	15	0.42	0.42	5.00	12.50	125.00	4.667	11,639.76	10.00	250.00	214.10	75.00	9.000E-06	0.0003	9.7	11.7	11.8	66.8	NA	0
	290.00	5	15	0.42	0.42	5.00	12.50	125.00	4.833	11,894.65	10.00	250.00	214.10	75.00	8.000E-06	0.0003	9.9	11.6	11.8	66.7	NA	0
15:10	300.00	5	15	0.42	0.42	5.00	12.50	125.00	5.000	12,149.53	10.00	250.00	214.10	75.00	7.000E-06	0.0003	9.8	11.6	11.9	66.7	NA	0
	310.00	5	15	0.42	0.42	5.00	12.50	125.00	5.167	12,404.42	10.00	250.00	214.10	75.00	6.000E-06	0.0002	9.5	11.4	11.7	67.4	NA	0
	320.00	5	15	0.42	0.42	5.00	12.50	125.00	5.333	12,659.30	10.00	250.00	214.10	75.00	5.000E-06	0.0002	9.6	11.3	11.7	67.4	NA	0
15:40	330.00	5	15	0.42	0.42	5.00	12.50	125.00	5.500	12,914.19	10.00	250.00	214.10	75.00	4.000E-06	0.0001	9.3	11.3	11.6	67.8	NA	0
	340.00	5	15	0.42	0.42	5.00	12.50	125.00	5.667	13,169.07	10.00	250.00	214.10	75.00	3.000E-06	0.0001	9.4	11.3	11.8	67.5	NA	0
	350.00	5	15	0.42	0.42	5.00	12.50	125.00	5.833	13,423.96	10.00	250.00	214.10	75.00	2.000E-06	0.0001	9.4	11.3	11.6	67.7	NA	0
16:10	360.00	5	15	0.42	0.42	5.00	12.50	125.00	6.000	13,678.84	10.00	250.00	214.10	75.00	1.000E-06	0.0000	9.3	11.2	11.6	67.9	NA	0

TABLE 3

MODIFIED TIER 3 ANALYSIS
(FLOW = 45 CFM AND 75 CFM)
12TH STREET LANDFILL
OTSEGO, MICHIGAN

Aavg = 40 yrs
Waste Density = 60 lbs/cf
Waste Density = 1.17 Mg/m3
Well Depth = 7.5 m
Rma = 5 m
Lo = 100 m3/Mg
f = 0.75

Site: 12th Street Landfill
Proj. No: 56393
Sample Location: GW-2
Date: 6/3/2009

Clock Time	Time (min)	Blower Vacuum (in WC)	LFG Flow Rate (Qi) (scfm)	LFG Flow Rate (Qi) (m3/min)	Stabilized Flow Rate (Qf) (m3/min)	Radius of Influence (Rsa) (m)	Depth Affected by Extraction Well (Dst) (m)	Extraction Well Void Volume (Vv) (m3)	Time of the ith Interval (tvi) (hr)	Total Volume of LFG Extracted from Well (Vt) (Vt >= 2 Vv) (m3)	Depth Affected by Extraction Well (D) (m)	Volume of Refuse Affected by Test Well (Vr) (m3)	Mass Affected by Test Well (Mi) (Mg)	Modified Methane Generation Potential (Lo') (m3/Mg)	Landfill Gas Generation Constant Calculation: Assumed k (1/yr)	Landfill Gas Generation Constant Calculation: Resultant (= 0.7)	Landfill Gas Quality Readings: Methane (%)	Landfill Gas Quality Readings: Carbon Dioxide (%)	Landfill Gas Quality Readings: Oxygen (%)	Balance (%)	Pressure Readings: LH-1 (in WC)	Pressure Readings: LH-2 (in WC)
8:30	0.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.000	0.00	10.00	250.00	214.10	75.00	1.000E+00	14.71514	10.9	13.8	6.6	69.7	NA	0
	5.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.083	382.33	10.00	250.00	214.10	75.00	5.000E-01	12.13057	10.6	13.7	6.9	69.8	NA	0
	10.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.167	764.66	10.00	250.00	214.10	75.00	1.000E-02	0.39598	10.2	13.6	6.4	69.8	NA	0
	15.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.250	1,146.98	10.00	250.00	214.10	75.00	9.000E-03	0.35673	9.9	13.5	7.7	68.9	NA	0
	20.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.333	1,529.31	10.00	250.00	214.10	75.00	8.000E-03	0.31741	9.8	13.5	7.8	69.1	NA	0
	25.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.417	1,911.64	10.00	250.00	214.10	75.00	7.000E-03	0.27801	9.5	13.6	8.9	68	NA	0
9:00	30.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.500	2,293.97	10.00	250.00	214.10	75.00	6.000E-03	0.23852	9.3	13.6	9.6	67.5	NA	0
	35.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.583	2,676.30	10.00	250.00	214.10	75.00	5.000E-03	0.19896	9.5	13	10.1	67.4	NA	0
	40.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.667	3,058.62	10.00	250.00	214.10	75.00	4.000E-03	0.15932	9.4	12.9	10.6	67.1	NA	0
	45.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.750	3,440.95	10.00	250.00	214.10	75.00	3.000E-03	0.11960	9.3	12.5	11.1	67.1	NA	0
	50.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.833	3,823.28	10.00	250.00	214.10	75.00	2.000E-03	0.07980	9.2	12.3	11.1	67.4	NA	0
	55.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	0.917	4,205.61	10.00	250.00	214.10	75.00	1.000E-03	0.03992	9.1	12.1	11.2	67.6	NA	0
9:30	60.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	1.000	4,587.94	10.00	250.00	214.10	75.00	9.000E-04	0.03593	9.1	12.1	11.2	67.6	NA	0
	65.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	1.083	4,970.26	10.00	250.00	214.10	75.00	8.000E-04	0.03193	9.1	12.1	11.6	67.2	NA	0
	70.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	1.167	5,352.59	10.00	250.00	214.10	75.00	7.000E-04	0.02794	9	12.1	11.8	67.1	NA	0
	75.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	1.250	5,734.92	10.00	250.00	214.10	75.00	6.000E-04	0.02395	9	11.9	11.9	67.2	NA	0
	80.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	1.333	6,117.25	10.00	250.00	214.10	75.00	5.000E-04	0.01995	9	11.7	12.2	67.1	NA	0
	85.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	1.417	6,499.58	10.00	250.00	214.10	75.00	4.000E-04	0.01595	8.9	11.4	11.9	67.9	NA	0
10:00	90.00	9.00	45.00	1.27	1.27	5.00	12.50	125.00	1.500	6,881.90	10.00	250.00	214.10	75.00	3.000E-04	0.01196	8.6	11.1	11.9	68.4	NA	0
	95.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	1.583	7,519.12	10.00	250.00	214.10	75.00	2.000E-04	0.00793	8.9	11.5	12.4	67.2	NA	0
	100.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	1.667	8,156.33	10.00	250.00	214.10	75.00	1.000E-04	0.00393	8.8	11.5	12.3	67.4	NA	0
	105.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	1.750	8,793.54	10.00	250.00	214.10	75.00	9.000E-05	0.00353	8.8	11.4	12.4	67.4	NA	0
	110.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	1.833	9,430.76	10.00	250.00	214.10	75.00	8.000E-05	0.00313	8.7	11.2	12.6	67.5	NA	0
	115.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	1.917	10,067.97	10.00	250.00	214.10	75.00	7.000E-05	0.00273	8.4	11.1	12.4	68.1	NA	0
10:30	120.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.000	10,705.18	10.00	250.00	214.10	75.00	6.000E-05	0.00233	8.4	11	12.8	67.8	NA	0
	125.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.083	11,342.40	10.00	250.00	214.10	75.00	5.000E-05	0.00193	8.2	10.8	13.2	67.8	NA	0
	130.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.167	11,979.61	10.00	250.00	214.10	75.00	4.000E-05	0.00153	8.2	10.7	13.1	68	NA	0
	135.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.250	12,616.82	10.00	250.00	214.10	75.00	3.000E-05	0.00113	8	10.5	13.2	68.3	NA	0
	140.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.333	13,254.04	10.00	250.00	214.10	75.00	2.000E-05	0.00073	7.9	10.4	13.3	68.4	NA	0
	145.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.417	13,891.25	10.00	250.00	214.10	75.00	1.000E-05	0.00033	7.7	10.2	13.4	68.7	NA	0
11:00	150.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.500	14,528.46	10.00	250.00	214.10	75.00	9.000E-06	0.00029	7.8	10.2	13.2	68.8	NA	0
	155.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.583	15,165.68	10.00	250.00	214.10	75.00	8.000E-06	0.00025	7.7	10.1	13.2	69	NA	0
	160.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.667	15,802.89	10.00	250.00	214.10	75.00	7.000E-06	0.00021	7.6	9.9	13.3	69.3	NA	0
	165.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.750	16,440.10	10.00	250.00	214.10	75.00	6.000E-06	0.00017	7.5	9.9	13.4	69.2	NA	0
	170.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.833	17,077.32	10.00	250.00	214.10	75.00	5.000E-06	0.00013	7.5	9.8	13.4	69.3	NA	0
	175.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	2.917	17,714.53	10.00	250.00	214.10	75.00	4.000E-06	0.00009	7.5	9.8	13.4	69.3	NA	0
11:30	180.00	12.50	75.00	2.12	2.12	5.00	12.50	125.00	3.000	18,351.74	10.00	250.00	214.10	75.00	3.000E-06	0.00005	7.4	9.8	13.4	69.4	NA	0

TABLE 4

LANDFILL GAS PRESSURE RELIEF LAYER CALCULATIONS
12TH STREET LANDFILL
OTSEGO, MICHIGAN

English

	tons	lb	
Landfill Waste	352,346	7.05E+08	
	ft^3/min	$ft^3/lb/min$	$ft^3/lb/yr$
r_g	15	2.13E-08	1.12E-02
	30	4.26E-08	2.24E-02
	45	6.39E-08	3.36E-02
	ft		
$H_{avg\ waste}$	30		
	lb/ft^3		
γ_{waste}	60		
	lb/ft^3		
γ_{LFG}	0.078		
γ_{H2O}	62.4		
	ft		
L	100		
	200		
	300		
	in WC	psi	lb/ft^2
u_{gmax}	10	0.36	52
	15	0.54	78
	20	0.72	104
	Centipoise	$lb\text{-}s/ft^2$	
u_{LFG}	0.0132	2.76E-07	
u_{H2O}	1.01	2.11E-05	

Metric

	kg			
Landfill Waste	3.20E+08			
	m^3/min	$m^3/kg/min$	$m^3/kg/yr$	$m^3/kg/s$
r_g	0.42	1.33E-09	6.99E-04	2.22E-11
	0.85	2.66E-09	1.40E-03	4.43E-11
	1.27	3.99E-09	2.10E-03	6.65E-11
	m			
$H_{avg\ waste}$	9.1			
	N/m^3			
γ_{waste}	9,430			
	kN/m^3	N/m^3		
γ_{LFG}	0.012	12.3		
γ_{H2O}	9.8	9800		
	m			
L	30.5			
	61.0			
	91.4			
	kPa	Pa	N/m^2	
u_{gmax}	2.49	2,489	2,489	
	3.73	3,733	3,733	
	4.98	4,978	4,978	
	$N\text{-}s/m^2$			
u_{LFG}	1.32E-05			
u_{H2O}	1.01E-03			

English

	r_g $ft^3/lb/s$	$H_{avg\ waste}$ ft	γ_{waste} lb/ft^3	Φ_{LFG} $ft^3/s/ft^2$	γ_{LFG} lb/ft^3	L ft	u_{gmax} lb/ft^2	$\theta_{required\ LFG}$ ft^2/s	u_{LFG} $lb\text{-}s/ft^2$	u_{H2O} $lb\text{-}s/ft^2$	γ_{H2O} lb/ft^3	θ_{H2O} ft^2/s	v_{LFG} ft/s	d_{LFG} ft	u_{LFG} ft^2/s	Re	RF_{in}	RF_{cr}	RF_{cc}	RF_{bc}	FS	$\theta_{ultimate\ LFG}$ ft^2/s
Minimum	3.55E-10	30	60	6.39E-07	0.078	100	52	1.20E-06	2.76E-07	2.11E-05	6.24E+01	1.25E-05	3.19E-07	100	1.09E-04	0.29	1	1.1	1	1.2	2	3.16E-06
Average	7.10E-10	30	60	1.28E-06	0.078	200	78	6.39E-06	2.76E-07	2.11E-05	6.24E+01	6.68E-05	6.39E-07	200	1.09E-04	1.17	1.1	1.25	1.1	1.35	2.5	3.26E-05
Maximum	1.06E-09	30	60	1.92E-06	0.078	300	104	1.62E-05	2.76E-07	2.11E-05	6.24E+01	1.69E-04	9.58E-07	300	1.09E-04	2.64	1.2	1.4	1.2	1.5	3	1.47E-04

Metric

	r_g $m^3/kg/s$	$H_{avg\ waste}$ m	γ_{waste} N/m^3	Φ_{LFG} $m^3/s/m^2$	γ_{LFG} N/m^3	L m	u_{gmax} N/m^3	$\theta_{required\ LFG}$ m^2/s	u_{LFG} $N\text{-}s/m^2$	u_{H2O} $N\text{-}s/m^2$	γ_{H2O} N/m^3	θ_{H2O} m^2/s	v_{LFG} m/s	d_{LFG} m	υ_{LFG} m^2/s	Re	RF_{in}	RF_{cr}	RF_{cc}	RF_{bc}	FS	$\theta_{ultimate\ LFG}$ m^2/s
Minimum	2.22E-11	9.1	9,430	1.95E-07	12.3	30.5	2,489	1.11E-07	1.32E-05	1.01E-03	9800	3.07E-06	9.73E-08	30.5	1.01E-05	0.29	1	1.1	1	1.2	2	2.94E-07
Average	4.43E-11	9.1	9,430	3.89E-07	12.3	61.0	3,733	5.94E-07	1.32E-05	1.01E-03	9800	3.17E-05	1.95E-07	61.0	1.01E-05	1.18	1.1	1.25	1.1	1.35	2.5	3.03E-06
Maximum	6.65E-11	9.1	9,430	5.84E-07	12.3	91.4	4,978	1.50E-06	1.32E-05	1.01E-03	9800	1.43E-04	2.92E-07	91.4	1.01E-05	2.64	1.2	1.4	1.2	1.5	3	1.36E-05

ATTACHMENT A
LFG MODELING RESULTS
(RMT PRE-FINAL DESIGN REPORT, JANUARY 2009)

Attachment 1
Landfill Gas Generation Model

2

Project: 12th Street Landfill
Data: Gas Control Efforts

Date: 01/12/09
By: DRF
Checked: ECW

Component	Generated(%) (Input)	Recycled(%)	Landfill Disposal(%)	Landfill Waste Characterization(%)
Food/ sludge	0.0	0.0	0.0	0.0
Garden waste	0.0	0.0	0.0	0.0
Paper products	100.0	0.0	100.0	100.0
Plastic/Rubber	0.0	0.0	0.0	0.0
Textiles	0.0	0.0	0.0	0.0
Wood	0.0	0.0	0.0	0.0
Rubble/Inerts	0.0	0.0	0.0	0.0
Total	100		100	100

02/11/09

12th Street Landfill
Waste Quantities

Year	Cubic Yards	Percent Inorganics	Waste Volume (CY)	Density (LBS/CY)	Total Tons
1955	11,111	0.0	11,111	2349	13,050
1956	11,111	0.0	11,111	2349	13,050
1957	11,111	0.0	11,111	2349	13,050
1958	11,111	0.0	11,111	2349	13,050
1959	11,111	0.0	11,111	2349	13,050
1960	11,111	0.0	11,111	2349	13,050
1961	11,111	0.0	11,111	2349	13,050
1962	11,111	0.0	11,111	2349	13,050
1963	11,111	0.0	11,111	2349	13,050
1964	11,111	0.0	11,111	2349	13,050
1965	11,111	0.0	11,111	2349	13,050
1966	11,111	0.0	11,111	2349	13,050
1967	11,111	0.0	11,111	2349	13,050
1968	11,111	0.0	11,111	2349	13,050
1969	11,111	0.0	11,111	2349	13,050
1970	11,111	0.0	11,111	2349	13,050
1971	11,111	0.0	11,111	2349	13,050
1972	11,111	0.0	11,111	2349	13,050
1973	11,111	0.0	11,111	2349	13,050
1974	11,111	0.0	11,111	2349	13,050
1975	11,111	0.0	11,111	2349	13,050
1976	11,111	0.0	11,111	2349	13,050
1977	11,111	0.0	11,111	2349	13,050
1978	11,111	0.0	11,111	2349	13,050
1979	11,111	0.0	11,111	2349	13,050
1980	11,111	0.0	11,111	2349	13,050
1981	11,111	0.0	11,111	2349	13,050
1982	0	0.0	0	0	0
1983	0	0.0	0	0	0
1984	0	0.0	0	0	0
1985	0	0.0	0	0	0
1986	0	0.0	0	0	0
1987	0	0.0	0	0	0
1988	0	0.0	0	0	0
TOTAL	299,997		299,997		352,346

Component	Compacted (from input)	Waste Characterization Loose	Composite	t@	t#
Food / sludge	0.0	0	0	1.5	3.5
Garden waste	0.0	0	0	7	30
Paper products	100.0	0	0	10	30
Plastic/Rubber	0.0	0	0	20	60
Textiles	0.0	0	0	7	20
Wood	0.0	0	0	15	50
Rubble/Inerts	0.0	0	0	0	0
Moisture Content (1)	50%	0%	0%		
Dry Solids	50%	0%	0%		
Volatile Solids - Weight Basis)	85%	0%	0%		
Volatile Solids)ry Wt. Basis)	80%	0%	0%		
Maximum Methane Production (2) (cu.ft./lbm)	2.86	0.00	0.00	2.86	(cu ft./lbm)

(1) Input composite moisture
(2) Maximum theoretical methane yield based on given weight and composition.
Reference "Methane Generation and Recovery From Landfills", Emcon Associates.

Methane Generation Calculation (4) 02/11/09

First Stage Equation:

$$G = (L/2)e^{-k1(t@ - t)}$$

Second Stage Equation:

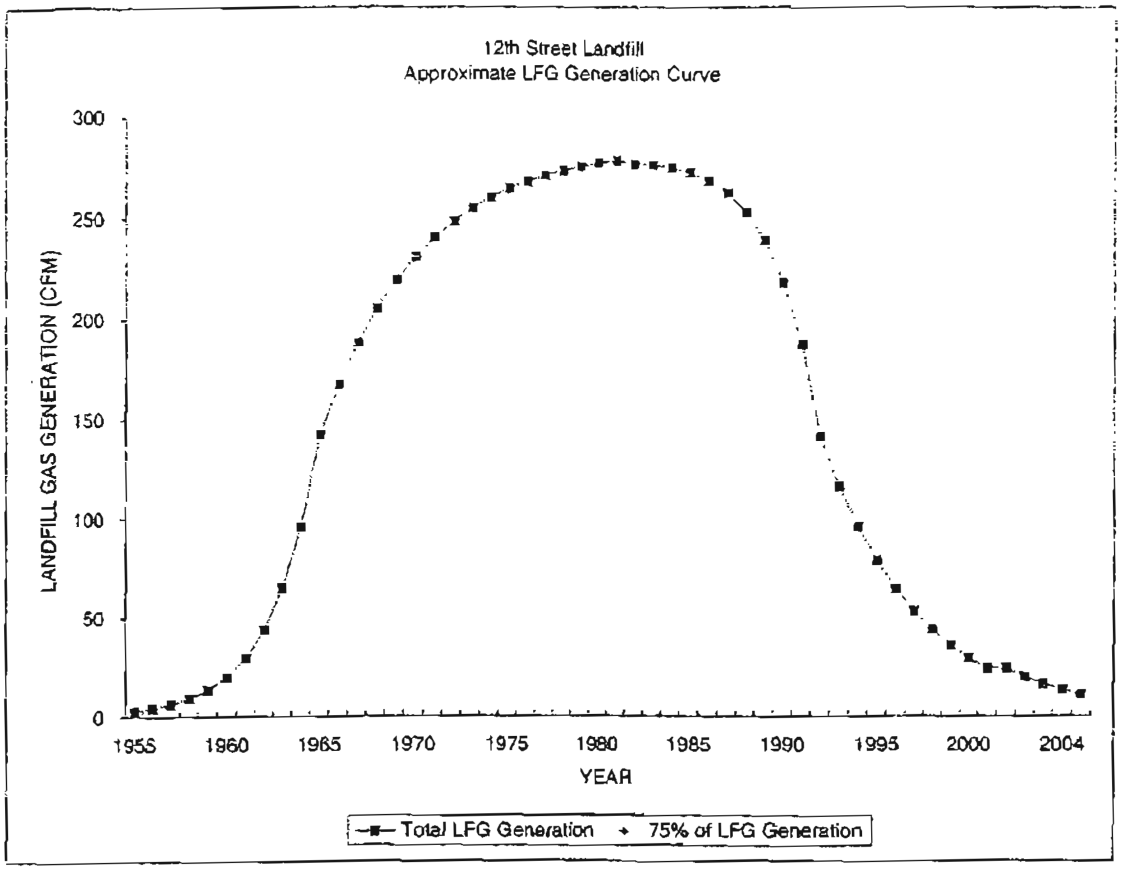
$$G = L[1 - .5e^{-k2(t - t@)}]$$

Where:
G = Volume of gas produced prior to time t
L = Maximum methane production
k1 = ln(50)/t@
k2 = ln(50)/(t# - t@)
t@ = time when 50% of methane has been produced in years
t# = time when 99% of methane has been produced in years

12th Street Landfill

02/11/09

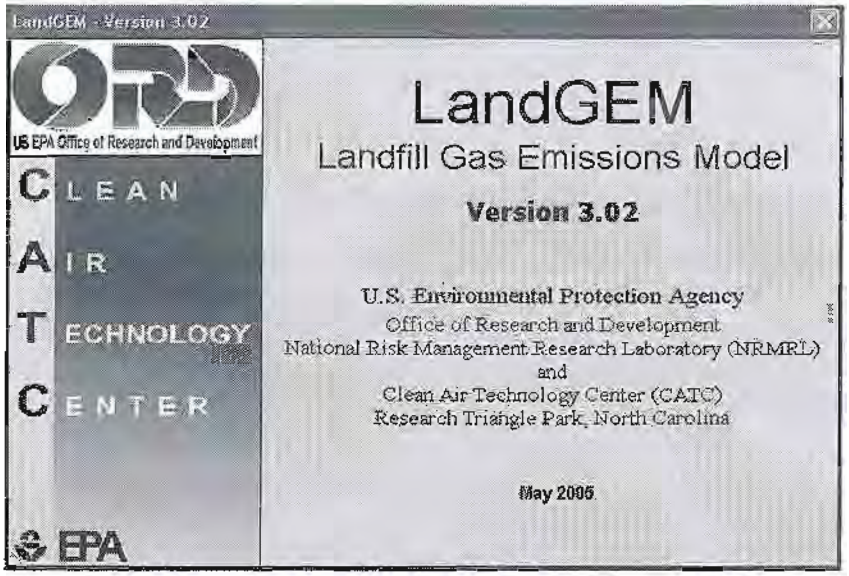
Methane (CFM)	Year	Total LFG
1	1955	3
2	1956	4
3	1957	6
5	1958	9
7	1959	14
10	1960	20
15	1961	30
22	1962	44
33	1963	65
48	1964	96
71	1965	142
84	1966	167
94	1967	188
103	1968	205
110	1969	219
115	1970	231
120	1971	240
124	1972	248
127	1973	255
130	1974	260
132	1975	264
134	1976	268
135	1977	271
137	1978	273
138	1979	275
138	1980	277
139	1981	278
138	1982	276
138	1983	276
137	1984	275
136	1985	272
134	1986	269
131	1987	262
127	1988	253
120	1989	239
109	1990	218
94	1991	187
71	1992	142
58	1993	116
48	1994	96
39	1995	79
32	1996	65
27	1997	53
22	1998	44
18	1999	36
15	2000	30
12	2001	24
12	2001	24
10	2002	20
8	2003	16
7	2004	14
6	2005	11



12th Street Landfill
Approximate LFG Generation Curve
LANDFILL GAS GENERATION (CFM)
300
250
200
150
100
50
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2004
YEAR
Total LFG Generation
75% of LFG Generation

6

ATTACHMENT B
LFG MODELING RESULTS



Summary Report

Landfill Name or Identifier: 12th Street Landfill

Date: Tuesday, June 16, 2009

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate *($year^{-1}$)*
L_o = potential methane generation capacity *(m^3/Mg)*

M_i = mass of waste accepted in the i^{th} year *(Mg)*
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year *(decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1955**	
Landfill Closure Year (with 80-year limit)	**1982**	
Actual Closure Year (without limit)	***1982***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*year^{-1}*
Potential Methane Generation Capacity, L_o	**179**	*m^3/Mg*
NMOC Concentration	**600**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1955	11,864	13,050	0	0
1956	11,864	13,050	11,864	13,050
1957	11,864	13,050	23,727	26,100
1958	11,864	13,050	35,591	39,150
1959	11,864	13,050	47,455	52,200
1960	11,864	13,050	59,318	65,250
1961	11,864	13,050	71,182	78,300
1962	11,864	13,050	83,045	91,350
1963	11,864	13,050	94,909	104,400
1964	11,864	13,050	106,773	117,450
1965	11,864	13,050	118,636	130,500
1966	11,864	13,050	130,500	143,550
1967	11,864	13,050	142,364	156,600
1968	11,864	13,050	154,227	169,650
1969	11,864	13,050	166,091	182,700
1970	11,864	13,050	177,955	195,750
1971	11,864	13,050	189,818	208,800
1972	11,864	13,050	201,682	221,850
1973	11,864	13,050	213,545	234,900
1974	11,864	13,050	225,409	247,950
1975	11,864	13,050	237,273	261,000
1976	11,864	13,050	249,136	274,050
1977	11,864	13,050	261,000	287,100
1978	11,864	13,050	272,864	300,150
1979	11,864	13,050	284,727	313,200
1980	11,864	13,050	296,591	326,250
1981	11,864	13,050	308,455	339,300
1982	0	0	320,318	352,350
1983	0	0	320,318	352,350
1984	0	0	320,318	352,350
1985	0	0	320,318	352,350
1986	0	0	320,318	352,350
1987	0	0	320,318	352,350
1988	0	0	320,318	352,350
1989	0	0	320,318	352,350
1990	0	0	320,318	352,350
1991	0	0	320,318	352,350
1992	0	0	320,318	352,350
1993	0	0	320,318	352,350
1994	0	0	320,318	352,350

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	(short tons/year)	(Mg)	(short tons)
1995	0	0	320,318	352,350
1996	0	0	320,318	352,350
1997	0	0	320,318	352,350
1998	0	0	320,318	352,350
1999	0	0	320,318	352,350
2000	0	0	320,318	352,350
2001	0	0	320,318	352,350
2002	0	0	320,318	352,350
2003	0	0	320,318	352,350
2004	0	0	320,318	352,350
2005	0	0	320,318	352,350
2006	0	0	320,318	352,350
2007	0	0	320,318	352,350
2008	0	0	320,318	352,350
2009	0	0	320,318	352,350
2010	0	0	320,318	352,350
2011	0	0	320,318	352,350
2012	0	0	320,318	352,350
2013	0	0	320,318	352,350
2014	0	0	320,318	352,350
2015	0	0	320,318	352,350
2016	0	0	320,318	352,350
2017	0	0	320,318	352,350
2018	0	0	320,318	352,350
2019	0	0	320,318	352,350
2020	0	0	320,318	352,350
2021	0	0	320,318	352,350
2022	0	0	320,318	352,350
2023	0	0	320,318	352,350
2024	0	0	320,318	352,350
2025	0	0	320,318	352,350
2026	0	0	320,318	352,350
2027	0	0	320,318	352,350
2028	0	0	320,318	352,350
2029	0	0	320,318	352,350
2030	0	0	320,318	352,350
2031	0	0	320,318	352,350
2032	0	0	320,318	352,350
2033	0	0	320,318	352,350
2034	0	0	320,318	352,350

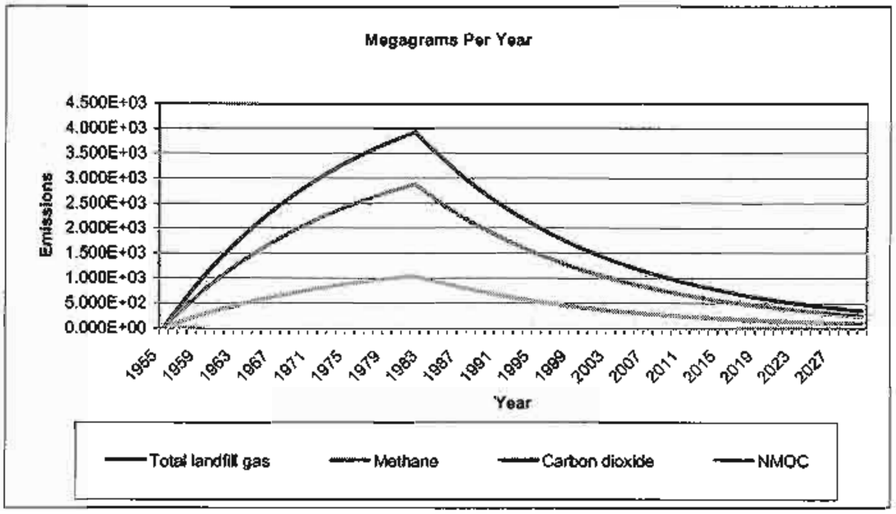
Pollutant Parameters

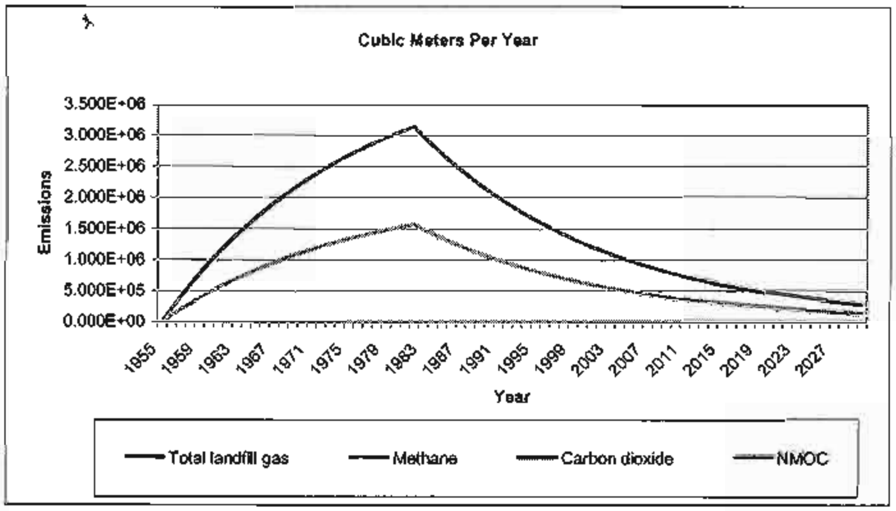
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

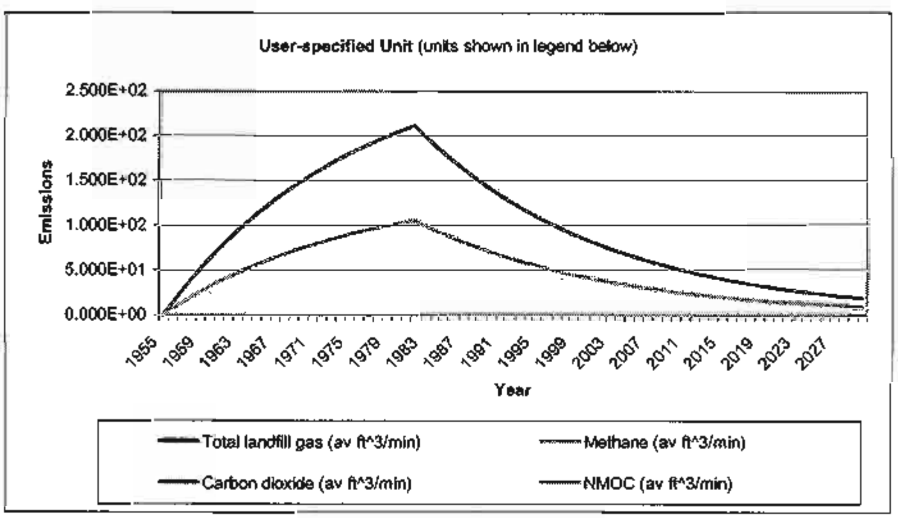
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
4.500E+03
4.000E+03
3.500E+03
3.000E+03
2.500E+03
2.000E+03
1.500E+03
1.000E+03
5.000E+02
0.000E+00
Emissions
1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
3.500E+06
3.000E+06
2.500E+06
2.000E+06
1.500E+06
1.000E+06
5.000E+05
0.000E+00
Emissions
1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
2.500E+02
2.000E+02
1.500E+02
1.000E+02
5.000E+01
0.000E+00
Emissions
1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
1955	0	0	0	0	0	0
1956	2.587E+02	2.071E+05	1.392E+01	6.909E+01	1.036E+05	6.958E+00
1957	5.047E+02	4.041E+05	2.715E+01	1.348E+02	2.021E+05	1.358E+01
1958	7.387E+02	5.916E+05	3.975E+01	1.973E+02	2.958E+05	1.987E+01
1959	9.614E+02	7.698E+05	5.172E+01	2.568E+02	3.849E+05	2.586E+01
1960	1.173E+03	9.394E+05	6.312E+01	3.134E+02	4.697E+05	3.156E+01
1961	1.375E+03	1.101E+06	7.396E+01	3.672E+02	5.504E+05	3.698E+01
1962	1.566E+03	1.254E+06	8.427E+01	4.184E+02	6.271E+05	4.213E+01
1963	1.748E+03	1.400E+06	9.407E+01	4.670E+02	7.001E+05	4.704E+01
1964	1.922E+03	1.539E+06	1.034E+02	5.134E+02	7.695E+05	5.170E+01
1965	2.087E+03	1.671E+06	1.123E+02	5.574E+02	8.355E+05	5.614E+01
1966	2.244E+03	1.797E+06	1.207E+02	5.993E+02	8.983E+05	6.036E+01
1967	2.393E+03	1.916E+06	1.287E+02	6.392E+02	9.581E+05	6.437E+01
1968	2.535E+03	2.030E+06	1.364E+02	6.771E+02	1.015E+06	6.819E+01
1969	2.670E+03	2.138E+06	1.436E+02	7.132E+02	1.069E+06	7.182E+01
1970	2.798E+03	2.241E+06	1.506E+02	7.475E+02	1.120E+06	7.528E+01
1971	2.921E+03	2.339E+06	1.571E+02	7.801E+02	1.169E+06	7.857E+01
1972	3.037E+03	2.432E+06	1.634E+02	8.111E+02	1.216E+06	8.169E+01
1973	3.147E+03	2.520E+06	1.693E+02	8.407E+02	1.260E+06	8.467E+01
1974	3.252E+03	2.604E+06	1.750E+02	8.688E+02	1.302E+06	8.750E+01
1975	3.353E+03	2.685E+06	1.804E+02	8.955E+02	1.342E+06	9.019E+01
1976	3.448E+03	2.761E+06	1.855E+02	9.209E+02	1.380E+06	9.275E+01
1977	3.538E+03	2.833E+06	1.904E+02	9.451E+02	1.417E+06	9.518E+01
1978	3.624E+03	2.902E+06	1.950E+02	9.681E+02	1.451E+06	9.750E+01
1979	3.706E+03	2.968E+06	1.994E+02	9.900E+02	1.484E+06	9.970E+01
1980	3.784E+03	3.030E+06	2.036E+02	1.011E+03	1.515E+06	1.018E+02
1981	3.858E+03	3.089E+06	2.076E+02	1.031E+03	1.545E+06	1.038E+02
1982	3.929E+03	3.146E+06	2.114E+02	1.049E+03	1.573E+06	1.057E+02
1983	3.737E+03	2.992E+06	2.011E+02	9.982E+02	1.496E+06	1.005E+02
1984	3.555E+03	2.847E+06	1.913E+02	9.495E+02	1.423E+06	9.563E+01
1985	3.381E+03	2.708E+06	1.819E+02	9.032E+02	1.354E+06	9.097E+01
1986	3.217E+03	2.576E+06	1.731E+02	8.592E+02	1.288E+06	8.653E+01
1987	3.060E+03	2.450E+06	1.646E+02	8.173E+02	1.225E+06	8.231E+01
1988	2.910E+03	2.331E+06	1.566E+02	7.774E+02	1.165E+06	7.829E+01
1989	2.768E+03	2.217E+06	1.490E+02	7.395E+02	1.108E+06	7.448E+01
1990	2.633E+03	2.109E+06	1.417E+02	7.034E+02	1.054E+06	7.084E+01
1991	2.505E+03	2.006E+06	1.348E+02	6.691E+02	1.003E+06	6.739E+01
1992	2.383E+03	1.908E+06	1.282E+02	6.365E+02	9.540E+05	6.410E+01
1993	2.267E+03	1.815E+06	1.220E+02	6.054E+02	9.075E+05	6.098E+01
1994	2.156E+03	1.727E+06	1.160E+02	5.759E+02	8.633E+05	5.800E+01
1995	2.051E+03	1.642E+06	1.103E+02	5.478E+02	8.212E+05	5.517E+01
1996	1.951E+03	1.562E+06	1.050E+02	5.211E+02	7.811E+05	5.248E+01
1997	1.856E+03	1.486E+06	9.985E+01	4.957E+02	7.430E+05	4.992E+01
1998	1.765E+03	1.414E+06	9.498E+01	4.715E+02	7.068E+05	4.749E+01
1999	1.679E+03	1.345E+06	9.034E+01	4.485E+02	6.723E+05	4.517E+01
2000	1.597E+03	1.279E+06	8.594E+01	4.267E+02	6.395E+05	4.297E+01
2001	1.519E+03	1.217E+06	8.175E+01	4.058E+02	6.083E+05	4.087E+01
2002	1.445E+03	1.157E+06	7.776E+01	3.861E+02	5.787E+05	3.888E+01
2003	1.375E+03	1.101E+06	7.397E+01	3.672E+02	5.504E+05	3.698E+01
2004	1.308E+03	1.047E+06	7.036E+01	3.493E+02	5.236E+05	3.518E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2005	1.244E+03	9.961E+05	6.693E+01	3.323E+02	4.981E+05	3.346E+01
2006	1.183E+03	9.475E+05	6.366E+01	3.161E+02	4.738E+05	3.183E+01
2007	1.126E+03	9.013E+05	6.056E+01	3.007E+02	4.507E+05	3.028E+01
2008	1.071E+03	8.574E+05	5.761E+01	2.860E+02	4.287E+05	2.880E+01
2009	1.018E+03	8.155E+05	5.480E+01	2.720E+02	4.078E+05	2.740E+01
2010	9.688E+02	7.758E+05	5.212E+01	2.588E+02	3.879E+05	2.606E+01
2011	9.216E+02	7.379E+05	4.958E+01	2.462E+02	3.690E+05	2.479E+01
2012	8.766E+02	7.019E+05	4.716E+01	2.342E+02	3.510E+05	2.358E+01
2013	8.339E+02	6.677E+05	4.486E+01	2.227E+02	3.339E+05	2.243E+01
2014	7.932E+02	6.351E+05	4.268E+01	2.119E+02	3.176E+05	2.134E+01
2015	7.545E+02	6.042E+05	4.059E+01	2.015E+02	3.021E+05	2.030E+01
2016	7.177E+02	5.747E+05	3.861E+01	1.917E+02	2.874E+05	1.931E+01
2017	6.827E+02	5.467E+05	3.673E+01	1.824E+02	2.733E+05	1.837E+01
2018	6.494E+02	5.200E+05	3.494E+01	1.735E+02	2.600E+05	1.747E+01
2019	6.177E+02	4.947E+05	3.324E+01	1.650E+02	2.473E+05	1.662E+01
2020	5.876E+02	4.705E+05	3.161E+01	1.570E+02	2.353E+05	1.581E+01
2021	5.589E+02	4.476E+05	3.007E+01	1.493E+02	2.238E+05	1.504E+01
2022	5.317E+02	4.258E+05	2.861E+01	1.420E+02	2.129E+05	1.430E+01
2023	5.058E+02	4.050E+05	2.721E+01	1.351E+02	2.025E+05	1.361E+01
2024	4.811E+02	3.852E+05	2.588E+01	1.285E+02	1.926E+05	1.294E+01
2025	4.576E+02	3.664E+05	2.462E+01	1.222E+02	1.832E+05	1.231E+01
2026	4.353E+02	3.486E+05	2.342E+01	1.163E+02	1.743E+05	1.171E+01
2027	4.141E+02	3.316E+05	2.228E+01	1.106E+02	1.658E+05	1.114E+01
2028	3.939E+02	3.154E+05	2.119E+01	1.052E+02	1.577E+05	1.060E+01
2029	3.747E+02	3.000E+05	2.016E+01	1.001E+02	1.500E+05	1.008E+01
2030	3.564E+02	2.854E+05	1.918E+01	9.520E+01	1.427E+05	9.588E+00
2031	3.390E+02	2.715E+05	1.824E+01	9.056E+01	1.357E+05	9.120E+00
2032	3.225E+02	2.582E+05	1.735E+01	8.614E+01	1.291E+05	8.675E+00
2033	3.068E+02	2.456E+05	1.650E+01	8.194E+01	1.228E+05	8.252E+00
2034	2.918E+02	2.337E+05	1.570E+01	7.794E+01	1.168E+05	7.850E+00
2035	2.776E+02	2.223E+05	1.493E+01	7.414E+01	1.111E+05	7.467E+00
2036	2.640E+02	2.114E+05	1.421E+01	7.053E+01	1.057E+05	7.103E+00
2037	2.512E+02	2.011E+05	1.351E+01	6.709E+01	1.006E+05	6.756E+00
2038	2.389E+02	1.913E+05	1.285E+01	6.381E+01	9.565E+04	6.427E+00
2039	2.273E+02	1.820E+05	1.223E+01	6.070E+01	9.099E+04	6.113E+00
2040	2.162E+02	1.731E+05	1.163E+01	5.774E+01	8.655E+04	5.815E+00
2041	2.056E+02	1.647E+05	1.106E+01	5.492E+01	8.233E+04	5.532E+00
2042	1.956E+02	1.566E+05	1.052E+01	5.225E+01	7.831E+04	5.262E+00
2043	1.861E+02	1.490E+05	1.001E+01	4.970E+01	7.449E+04	5.005E+00
2044	1.770E+02	1.417E+05	9.522E+00	4.727E+01	7.086E+04	4.761E+00
2045	1.684E+02	1.348E+05	9.058E+00	4.497E+01	6.740E+04	4.529E+00
2046	1.601E+02	1.282E+05	8.616E+00	4.278E+01	6.412E+04	4.308E+00
2047	1.523E+02	1.220E+05	8.196E+00	4.069E+01	6.099E+04	4.098E+00
2048	1.449E+02	1.160E+05	7.796E+00	3.870E+01	5.802E+04	3.898E+00
2049	1.378E+02	1.104E+05	7.416E+00	3.682E+01	5.519E+04	3.708E+00
2050	1.311E+02	1.050E+05	7.054E+00	3.502E+01	5.249E+04	3.527E+00
2051	1.247E+02	9.987E+04	6.710E+00	3.331E+01	4.993E+04	3.355E+00
2052	1.186E+02	9.500E+04	6.383E+00	3.169E+01	4.750E+04	3.191E+00
2053	1.129E+02	9.037E+04	6.072E+00	3.014E+01	4.518E+04	3.036E+00
2054	1.073E+02	8.596E+04	5.776E+00	2.867E+01	4.298E+04	2.888E+00
2055	1.021E+02	8.177E+04	5.494E+00	2.727E+01	4.088E+04	2.747E+00

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2056	9.713E+01	7.778E+04	5.226E+00	2.594E+01	3.889E+04	2.613E+00
2057	9.239E+01	7.398E+04	4.971E+00	2.468E+01	3.699E+04	2.486E+00
2058	8.789E+01	7.038E+04	4.729E+00	2.348E+01	3.519E+04	2.364E+00
2059	8.360E+01	6.694E+04	4.498E+00	2.233E+01	3.347E+04	2.249E+00
2060	7.952E+01	6.368E+04	4.279E+00	2.124E+01	3.184E+04	2.139E+00
2061	7.565E+01	6.057E+04	4.070E+00	2.021E+01	3.029E+04	2.035E+00
2062	7.196E+01	5.762E+04	3.871E+00	1.922E+01	2.881E+04	1.936E+00
2063	6.845E+01	5.481E+04	3.683E+00	1.828E+01	2.740E+04	1.841E+00
2064	6.511E+01	5.214E+04	3.503E+00	1.739E+01	2.607E+04	1.752E+00
2065	6.193E+01	4.959E+04	3.332E+00	1.654E+01	2.480E+04	1.666E+00
2066	5.891E+01	4.717E+04	3.170E+00	1.574E+01	2.359E+04	1.585E+00
2067	5.604E+01	4.487E+04	3.015E+00	1.497E+01	2.244E+04	1.508E+00
2068	5.331E+01	4.269E+04	2.868E+00	1.424E+01	2.134E+04	1.434E+00
2069	5.071E+01	4.060E+04	2.728E+00	1.354E+01	2.030E+04	1.364E+00
2070	4.823E+01	3.862E+04	2.595E+00	1.288E+01	1.931E+04	1.298E+00
2071	4.588E+01	3.674E+04	2.469E+00	1.226E+01	1.837E+04	1.234E+00
2072	4.364E+01	3.495E+04	2.348E+00	1.166E+01	1.747E+04	1.174E+00
2073	4.152E+01	3.324E+04	2.234E+00	1.109E+01	1.662E+04	1.117E+00
2074	3.949E+01	3.162E+04	2.125E+00	1.055E+01	1.581E+04	1.062E+00
2075	3.756E+01	3.008E+04	2.021E+00	1.003E+01	1.504E+04	1.011E+00
2076	3.573E+01	2.861E+04	1.922E+00	9.545E+00	1.431E+04	9.612E-01
2077	3.399E+01	2.722E+04	1.829E+00	9.079E+00	1.361E+04	9.144E-01
2078	3.233E+01	2.589E+04	1.740E+00	8.636E+00	1.295E+04	8.698E-01
2079	3.076E+01	2.463E+04	1.655E+00	8.215E+00	1.231E+04	8.274E-01
2080	2.926E+01	2.343E+04	1.574E+00	7.814E+00	1.171E+04	7.870E-01
2081	2.783E+01	2.228E+04	1.497E+00	7.433E+00	1.114E+04	7.486E-01
2082	2.647E+01	2.120E+04	1.424E+00	7.071E+00	1.060E+04	7.121E-01
2083	2.518E+01	2.016E+04	1.355E+00	6.726E+00	1.008E+04	6.774E-01
2084	2.395E+01	1.918E+04	1.289E+00	6.398E+00	9.590E+03	6.443E-01
2085	2.278E+01	1.824E+04	1.226E+00	6.086E+00	9.122E+03	6.129E-01
2086	2.167E+01	1.735E+04	1.166E+00	5.789E+00	8.677E+03	5.830E-01
2087	2.062E+01	1.651E+04	1.109E+00	5.507E+00	8.254E+03	5.546E-01
2088	1.961E+01	1.570E+04	1.055E+00	5.238E+00	7.852E+03	5.275E-01
2089	1.865E+01	1.494E+04	1.004E+00	4.983E+00	7.469E+03	5.018E-01
2090	1.774E+01	1.421E+04	9.547E-01	4.740E+00	7.104E+03	4.773E-01
2091	1.688E+01	1.352E+04	9.081E-01	4.509E+00	6.758E+03	4.541E-01
2092	1.606E+01	1.286E+04	8.638E-01	4.289E+00	6.428E+03	4.319E-01
2093	1.527E+01	1.223E+04	8.217E-01	4.079E+00	6.115E+03	4.109E-01
2094	1.453E+01	1.163E+04	7.816E-01	3.881E+00	5.817E+03	3.908E-01
2095	1.382E+01	1.107E+04	7.435E-01	3.691E+00	5.533E+03	3.718E-01

Results (Continued)

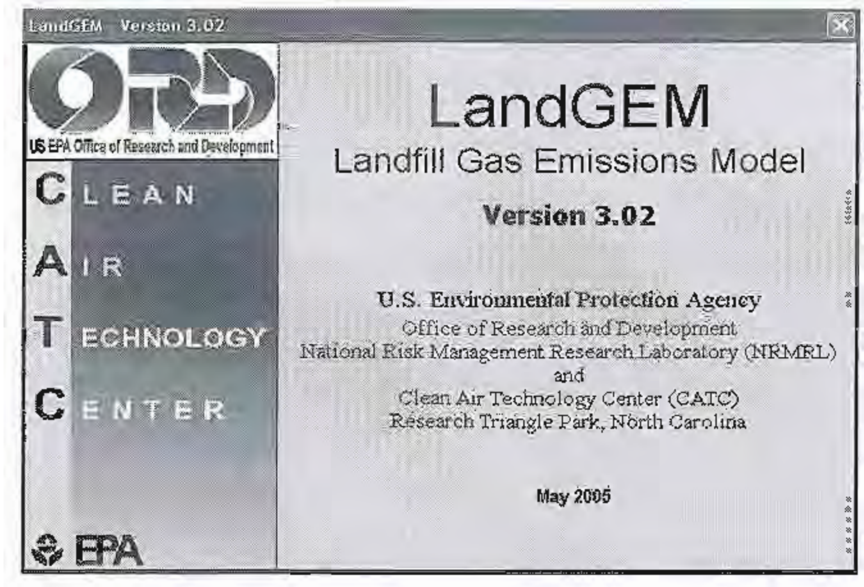
Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1955	0	0	0	0	0	0
1956	1.896E+02	1.036E+05	6.958E+00	4.455E-01	1.243E+02	8.350E-03
1957	3.699E+02	2.021E+05	1.358E+01	8.692E-01	2.425E+02	1.629E-02
1958	5.414E+02	2.958E+05	1.987E+01	1.272E+00	3.549E+02	2.385E-02
1959	7.046E+02	3.849E+05	2.586E+01	1.656E+00	4.619E+02	3.103E-02
1960	8.598E+02	4.697E+05	3.156E+01	2.020E+00	5.636E+02	3.787E-02
1961	1.007E+03	5.504E+05	3.698E+01	2.367E+00	6.604E+02	4.437E-02
1962	1.148E+03	6.271E+05	4.213E+01	2.697E+00	7.525E+02	5.056E-02
1963	1.281E+03	7.001E+05	4.704E+01	3.011E+00	8.401E+02	5.644E-02
1964	1.409E+03	7.695E+05	5.170E+01	3.310E+00	9.234E+02	6.204E-02
1965	1.529E+03	8.355E+05	5.614E+01	3.594E+00	1.003E+03	6.737E-02
1966	1.644E+03	8.983E+05	6.036E+01	3.864E+00	1.078E+03	7.243E-02
1967	1.754E+03	9.581E+05	6.437E+01	4.121E+00	1.150E+03	7.725E-02
1968	1.858E+03	1.015E+06	6.819E+01	4.365E+00	1.218E+03	8.183E-02
1969	1.957E+03	1.069E+06	7.182E+01	4.598E+00	1.283E+03	8.619E-02
1970	2.051E+03	1.120E+06	7.528E+01	4.819E+00	1.344E+03	9.034E-02
1971	2.140E+03	1.169E+06	7.857E+01	5.030E+00	1.403E+03	9.428E-02
1972	2.226E+03	1.216E+06	8.169E+01	5.230E+00	1.459E+03	9.803E-02
1973	2.307E+03	1.260E+06	8.467E+01	5.420E+00	1.512E+03	1.016E-01
1974	2.384E+03	1.302E+06	8.750E+01	5.601E+00	1.563E+03	1.050E-01
1975	2.457E+03	1.342E+06	9.019E+01	5.774E+00	1.611E+03	1.082E-01
1976	2.527E+03	1.380E+06	9.275E+01	5.937E+00	1.656E+03	1.113E-01
1977	2.593E+03	1.417E+06	9.518E+01	6.093E+00	1.700E+03	1.142E-01
1978	2.656E+03	1.451E+06	9.750E+01	6.242E+00	1.741E+03	1.170E-01
1979	2.716E+03	1.484E+06	9.970E+01	6.383E+00	1.781E+03	1.196E-01
1980	2.773E+03	1.515E+06	1.018E+02	6.517E+00	1.818E+03	1.222E-01
1981	2.828E+03	1.545E+06	1.038E+02	6.644E+00	1.854E+03	1.245E-01
1982	2.879E+03	1.573E+06	1.057E+02	6.766E+00	1.888E+03	1.268E-01
1983	2.739E+03	1.496E+06	1.005E+02	6.436E+00	1.795E+03	1.206E-01
1984	2.605E+03	1.423E+06	9.563E+01	6.122E+00	1.708E+03	1.148E-01
1985	2.478E+03	1.354E+06	9.097E+01	5.823E+00	1.625E+03	1.092E-01
1986	2.357E+03	1.288E+06	8.653E+01	5.539E+00	1.545E+03	1.038E-01
1987	2.242E+03	1.225E+06	8.231E+01	5.269E+00	1.470E+03	9.877E-02
1988	2.133E+03	1.165E+06	7.829E+01	5.012E+00	1.398E+03	9.395E-02
1989	2.029E+03	1.108E+06	7.448E+01	4.768E+00	1.330E+03	8.937E-02
1990	1.930E+03	1.054E+06	7.084E+01	4.535E+00	1.265E+03	8.501E-02
1991	1.836E+03	1.003E+06	6.739E+01	4.314E+00	1.204E+03	8.087E-02
1992	1.746E+03	9.540E+05	6.410E+01	4.104E+00	1.145E+03	7.692E-02
1993	1.661E+03	9.075E+05	6.098E+01	3.904E+00	1.089E+03	7.317E-02
1994	1.580E+03	8.633E+05	5.800E+01	3.713E+00	1.036E+03	6.960E-02
1995	1.503E+03	8.212E+05	5.517E+01	3.532E+00	9.854E+02	6.621E-02
1996	1.430E+03	7.811E+05	5.248E+01	3.360E+00	9.373E+02	6.298E-02
1997	1.360E+03	7.430E+05	4.992E+01	3.196E+00	8.916E+02	5.991E-02
1998	1.294E+03	7.068E+05	4.749E+01	3.040E+00	8.481E+02	5.699E-02
1999	1.231E+03	6.723E+05	4.517E+01	2.892E+00	8.068E+02	5.421E-02
2000	1.171E+03	6.395E+05	4.297E+01	2.751E+00	7.674E+02	5.156E-02
2001	1.114E+03	6.083E+05	4.087E+01	2.617E+00	7.300E+02	4.905E-02
2002	1.059E+03	5.787E+05	3.888E+01	2.489E+00	6.944E+02	4.666E-02
2003	1.008E+03	5.504E+05	3.698E+01	2.368E+00	6.605E+02	4.438E-02
2004	9.584E+02	5.236E+05	3.518E+01	2.252E+00	6.283E+02	4.222E-02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2005	9.117E+02	4.981E+05	3.346E+01	2.142E+00	5.977E+02	4.016E-02
2006	8.672E+02	4.738E+05	3.183E+01	2.038E+00	5.685E+02	3.820E-02
2007	8.249E+02	4.507E+05	3.028E+01	1.938E+00	5.408E+02	3.634E-02
2008	7.847E+02	4.287E+05	2.880E+01	1.844E+00	5.144E+02	3.456E-02
2009	7.464E+02	4.078E+05	2.740E+01	1.754E+00	4.893E+02	3.288E-02
2010	7.100E+02	3.879E+05	2.606E+01	1.668E+00	4.655E+02	3.127E-02
2011	6.754E+02	3.690E+05	2.479E+01	1.587E+00	4.428E+02	2.975E-02
2012	6.425E+02	3.510E+05	2.358E+01	1.510E+00	4.212E+02	2.830E-02
2013	6.111E+02	3.339E+05	2.243E+01	1.436E+00	4.006E+02	2.692E-02
2014	5.813E+02	3.176E+05	2.134E+01	1.366E+00	3.811E+02	2.561E-02
2015	5.530E+02	3.021E+05	2.030E+01	1.299E+00	3.625E+02	2.436E-02
2016	5.260E+02	2.874E+05	1.931E+01	1.236E+00	3.448E+02	2.317E-02
2017	5.003E+02	2.733E+05	1.837E+01	1.176E+00	3.280E+02	2.204E-02
2018	4.759E+02	2.600E+05	1.747E+01	1.118E+00	3.120E+02	2.096E-02
2019	4.527E+02	2.473E+05	1.662E+01	1.064E+00	2.968E+02	1.994E-02
2020	4.307E+02	2.353E+05	1.581E+01	1.012E+00	2.823E+02	1.897E-02
2021	4.096E+02	2.238E+05	1.504E+01	9.626E-01	2.685E+02	1.804E-02
2022	3.897E+02	2.129E+05	1.430E+01	9.157E-01	2.555E+02	1.716E-02
2023	3.707E+02	2.025E+05	1.361E+01	8.710E-01	2.430E+02	1.633E-02
2024	3.526E+02	1.926E+05	1.294E+01	8.285E-01	2.311E+02	1.553E-02
2025	3.354E+02	1.832E+05	1.231E+01	7.881E-01	2.199E+02	1.477E-02
2026	3.190E+02	1.743E+05	1.171E+01	7.497E-01	2.091E+02	1.405E-02
2027	3.035E+02	1.658E+05	1.114E+01	7.131E-01	1.989E+02	1.337E-02
2028	2.887E+02	1.577E+05	1.060E+01	6.783E-01	1.892E+02	1.272E-02
2029	2.746E+02	1.500E+05	1.008E+01	6.453E-01	1.800E+02	1.210E-02
2030	2.612E+02	1.427E+05	9.588E+00	6.138E-01	1.712E+02	1.151E-02
2031	2.485E+02	1.357E+05	9.120E+00	5.838E-01	1.629E+02	1.094E-02
2032	2.363E+02	1.291E+05	8.675E+00	5.554E-01	1.549E+02	1.041E-02
2033	2.248E+02	1.228E+05	8.252E+00	5.283E-01	1.474E+02	9.903E-03
2034	2.139E+02	1.168E+05	7.850E+00	5.025E-01	1.402E+02	9.420E-03
2035	2.034E+02	1.111E+05	7.467E+00	4.780E-01	1.334E+02	8.960E-03
2036	1.935E+02	1.057E+05	7.103E+00	4.547E-01	1.269E+02	8.523E-03
2037	1.841E+02	1.006E+05	6.756E+00	4.325E-01	1.207E+02	8.108E-03
2038	1.751E+02	9.565E+04	6.427E+00	4.114E-01	1.148E+02	7.712E-03
2039	1.666E+02	9.099E+04	6.113E+00	3.914E-01	1.092E+02	7.336E-03
2040	1.584E+02	8.655E+04	5.815E+00	3.723E-01	1.039E+02	6.978E-03
2041	1.507E+02	8.233E+04	5.532E+00	3.541E-01	9.879E+01	6.638E-03
2042	1.434E+02	7.831E+04	5.262E+00	3.369E-01	9.398E+01	6.314E-03
2043	1.364E+02	7.449E+04	5.005E+00	3.204E-01	8.939E+01	6.006E-03
2044	1.297E+02	7.086E+04	4.761E+00	3.048E-01	8.503E+01	5.713E-03
2045	1.234E+02	6.740E+04	4.529E+00	2.899E-01	8.089E+01	5.435E-03
2046	1.174E+02	6.412E+04	4.308E+00	2.758E-01	7.694E+01	5.170E-03
2047	1.116E+02	6.099E+04	4.098E+00	2.623E-01	7.319E+01	4.917E-03
2048	1.062E+02	5.802E+04	3.898E+00	2.495E-01	6.962E+01	4.678E-03
2049	1.010E+02	5.519E+04	3.708E+00	2.374E-01	6.622E+01	4.450E-03
2050	9.609E+01	5.249E+04	3.527E+00	2.258E-01	6.299E+01	4.233E-03
2051	9.140E+01	4.993E+04	3.355E+00	2.148E-01	5.992E+01	4.026E-03
2052	8.695E+01	4.750E+04	3.191E+00	2.043E-01	5.700E+01	3.830E-03
2053	8.271E+01	4.518E+04	3.036E+00	1.943E-01	5.422E+01	3.643E-03
2054	7.867E+01	4.298E+04	2.888E+00	1.849E-01	5.157E+01	3.465E-03
2055	7.484E+01	4.088E+04	2.747E+00	1.759E-01	4.906E+01	3.296E-03

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2056	7.119E+01	3.889E+04	2.613E+00	1.673E-01	4.667E+01	3.136E-03
2057	6.771E+01	3.699E+04	2.486E+00	1.591E-01	4.439E+01	2.983E-03
2058	6.441E+01	3.519E+04	2.364E+00	1.514E-01	4.223E+01	2.837E-03
2059	6.127E+01	3.347E+04	2.249E+00	1.440E-01	4.017E+01	2.699E-03
2060	5.828E+01	3.184E+04	2.139E+00	1.370E-01	3.821E+01	2.567E-03
2061	5.544E+01	3.029E+04	2.035E+00	1.303E-01	3.634E+01	2.442E-03
2062	5.274E+01	2.881E+04	1.936E+00	1.239E-01	3.457E+01	2.323E-03
2063	5.016E+01	2.740E+04	1.841E+00	1.179E-01	3.289E+01	2.210E-03
2064	4.772E+01	2.607E+04	1.752E+00	1.121E-01	3.128E+01	2.102E-03
2065	4.539E+01	2.480E+04	1.666E+00	1.067E-01	2.976E+01	1.999E-03
2066	4.318E+01	2.359E+04	1.585E+00	1.015E-01	2.830E+01	1.902E-03
2067	4.107E+01	2.244E+04	1.508E+00	9.651E-02	2.692E+01	1.809E-03
2068	3.907E+01	2.134E+04	1.434E+00	9.180E-02	2.561E+01	1.721E-03
2069	3.716E+01	2.030E+04	1.364E+00	8.733E-02	2.436E+01	1.637E-03
2070	3.535E+01	1.931E+04	1.298E+00	8.307E-02	2.317E+01	1.557E-03
2071	3.363E+01	1.837E+04	1.234E+00	7.902E-02	2.204E+01	1.481E-03
2072	3.199E+01	1.747E+04	1.174E+00	7.516E-02	2.097E+01	1.409E-03
2073	3.043E+01	1.662E+04	1.117E+00	7.150E-02	1.995E+01	1.340E-03
2074	2.894E+01	1.581E+04	1.062E+00	6.801E-02	1.897E+01	1.275E-03
2075	2.753E+01	1.504E+04	1.011E+00	6.469E-02	1.805E+01	1.213E-03
2076	2.619E+01	1.431E+04	9.612E-01	6.154E-02	1.717E+01	1.153E-03
2077	2.491E+01	1.361E+04	9.144E-01	5.854E-02	1.633E+01	1.097E-03
2078	2.370E+01	1.295E+04	8.698E-01	5.568E-02	1.553E+01	1.044E-03
2079	2.254E+01	1.231E+04	8.274E-01	5.297E-02	1.478E+01	9.928E-04
2080	2.144E+01	1.171E+04	7.870E-01	5.038E-02	1.406E+01	9.444E-04
2081	2.040E+01	1.114E+04	7.486E-01	4.793E-02	1.337E+01	8.983E-04
2082	1.940E+01	1.060E+04	7.121E-01	4.559E-02	1.272E+01	8.545E-04
2083	1.845E+01	1.008E+04	6.774E-01	4.336E-02	1.210E+01	8.129E-04
2084	1.755E+01	9.590E+03	6.443E-01	4.125E-02	1.151E+01	7.732E-04
2085	1.670E+01	9.122E+03	6.129E-01	3.924E-02	1.095E+01	7.355E-04
2086	1.588E+01	8.677E+03	5.830E-01	3.732E-02	1.041E+01	6.996E-04
2087	1.511E+01	8.254E+03	5.546E-01	3.550E-02	9.905E+00	6.655E-04
2088	1.437E+01	7.852E+03	5.275E-01	3.377E-02	9.422E+00	6.331E-04
2089	1.367E+01	7.469E+03	5.018E-01	3.213E-02	8.962E+00	6.022E-04
2090	1.300E+01	7.104E+03	4.773E-01	3.056E-02	8.525E+00	5.728E-04
2091	1.237E+01	6.758E+03	4.541E-01	2.907E-02	8.109E+00	5.449E-04
2092	1.177E+01	6.428E+03	4.319E-01	2.765E-02	7.714E+00	5.183E-04
2093	1.119E+01	6.115E+03	4.109E-01	2.630E-02	7.338E+00	4.930E-04
2094	1.065E+01	5.817E+03	3.908E-01	2.502E-02	6.980E+00	4.690E-04
2095	1.013E+01	5.533E+03	3.718E-01	2.380E-02	6.639E+00	4.461E-04



Summary Report

Landfill Name or Identifier: 12th Street Landfill

Date: Tuesday, June 16, 2009

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation (*m^3/year*)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1955**	
Landfill Closure Year (with 80-year limit)	**1982**	
Actual Closure Year (without limit)	***1982***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*year^{-1}*
Potential Methane Generation Capacity, L_o	**179**	*m^3/Mg*
NMOC Concentration	**600**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1955	8,898	9,788	0	0
1956	8,898	9,788	8,898	9,788
1957	8,898	9,788	17,795	19,575
1958	8,898	9,788	26,693	29,363
1959	8,898	9,788	35,591	39,150
1960	8,898	9,788	44,489	48,938
1961	8,898	9,788	53,386	58,725
1962	8,898	9,788	62,284	68,513
1963	8,898	9,788	71,182	78,300
1964	8,898	9,788	80,080	88,088
1965	8,898	9,788	88,977	97,875
1966	8,898	9,788	97,875	107,663
1967	8,898	9,788	106,773	117,450
1968	8,898	9,788	115,670	127,238
1969	8,898	9,788	124,568	137,025
1970	8,898	9,788	133,466	146,813
1971	8,898	9,788	142,364	156,600
1972	8,898	9,788	151,261	166,388
1973	8,898	9,788	160,159	176,175
1974	8,898	9,788	169,057	185,963
1975	8,898	9,788	177,955	195,750
1976	8,898	9,788	186,852	205,538
1977	8,898	9,788	195,750	215,325
1978	8,898	9,788	204,648	225,113
1979	8,898	9,788	213,545	234,900
1980	8,898	9,788	222,443	244,688
1981	8,898	9,788	231,341	254,475
1982	0	0	240,239	264,263
1983	0	0	240,239	264,263
1984	0	0	240,239	264,263
1985	0	0	240,239	264,263
1986	0	0	240,239	264,263
1987	0	0	240,239	264,263
1988	0	0	240,239	264,263
1989	0	0	240,239	264,263
1990	0	0	240,239	264,263
1991	0	0	240,239	264,263
1992	0	0	240,239	264,263
1993	0	0	240,239	264,263
1994	0	0	240,239	264,263

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1995	0	0	240,239	264,263
1996	0	0	240,239	264,263
1997	0	0	240,239	264,263
1998	0	0	240,239	264,263
1999	0	0	240,239	264,263
2000	0	0	240,239	264,263
2001	0	0	240,239	264,263
2002	0	0	240,239	264,263
2003	0	0	240,239	264,263
2004	0	0	240,239	264,263
2005	0	0	240,239	264,263
2006	0	0	240,239	264,263
2007	0	0	240,239	264,263
2008	0	0	240,239	264,263
2009	0	0	240,239	264,263
2010	0	0	240,239	264,263
2011	0	0	240,239	264,263
2012	0	0	240,239	264,263
2013	0	0	240,239	264,263
2014	0	0	240,239	264,263
2015	0	0	240,239	264,263
2016	0	0	240,239	264,263
2017	0	0	240,239	264,263
2018	0	0	240,239	264,263
2019	0	0	240,239	264,263
2020	0	0	240,239	264,263
2021	0	0	240,239	264,263
2022	0	0	240,239	264,263
2023	0	0	240,239	264,263
2024	0	0	240,239	264,263
2025	0	0	240,239	264,263
2026	0	0	240,239	264,263
2027	0	0	240,239	264,263
2028	0	0	240,239	264,263
2029	0	0	240,239	264,263
2030	0	0	240,239	264,263
2031	0	0	240,239	264,263
2032	0	0	240,239	264,263
2033	0	0	240,239	264,263
2034	0	0	240,239	264,263

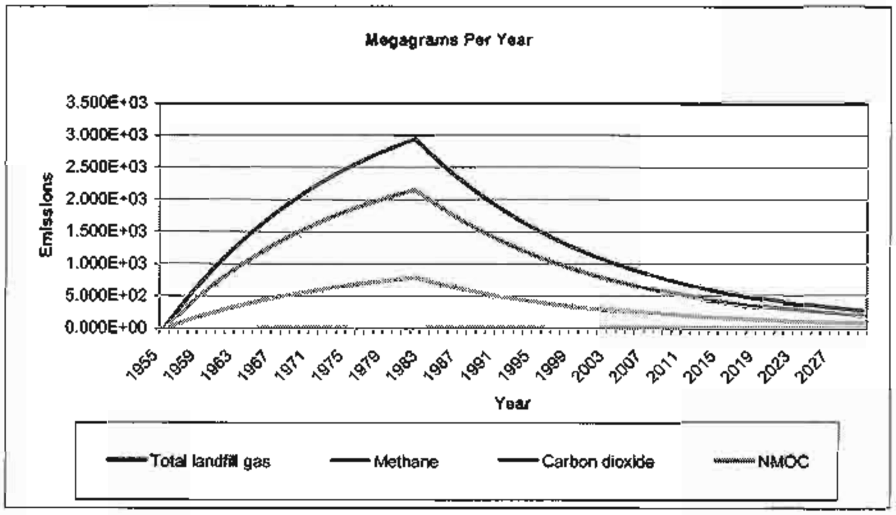
Pollutant Parameters

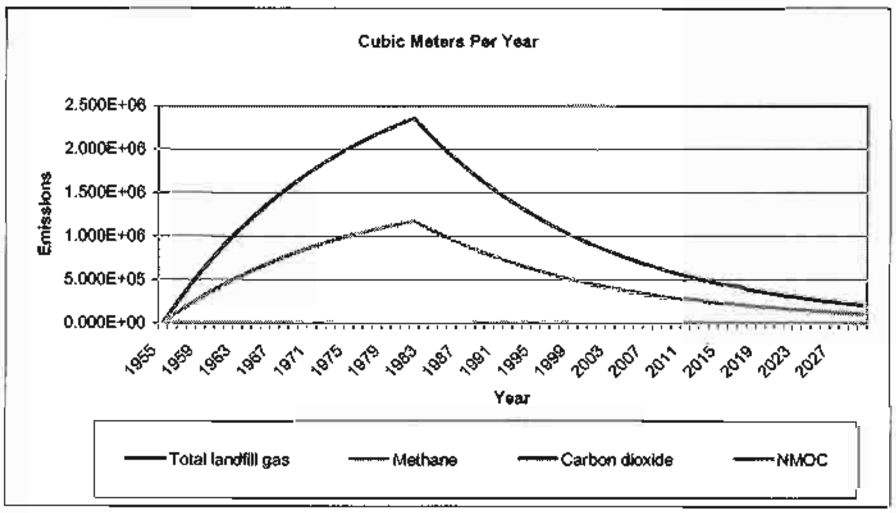
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (ppmv)	Molecular Weight	Concentration (ppmv)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

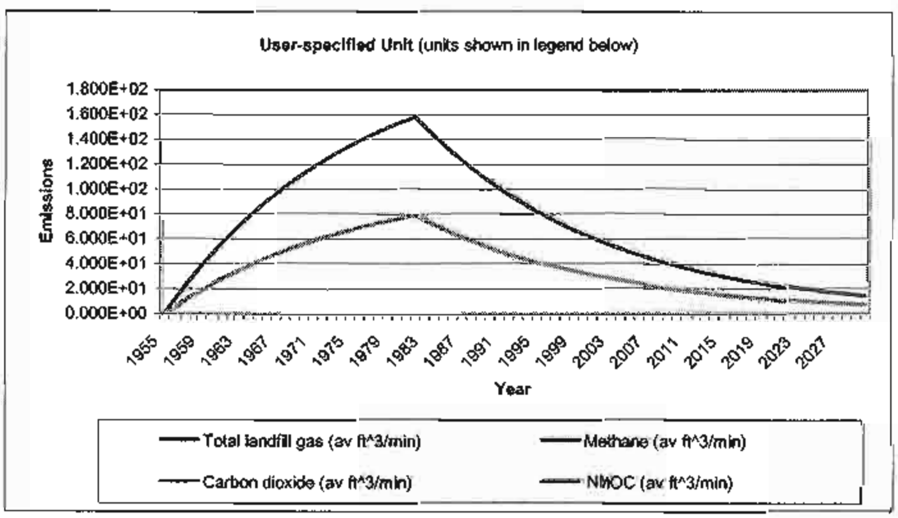
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
3.500E+03
3.000E+03
2.500E+03
2.000E+03
1.500E+03
1.000E+03
5.000E+02
0.000E+00
Emissions
1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
2.500E+06
2.000E+06
1.500E+06
1.000E+06
5.000E+05
0.000E+00
Emissions
1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
1.800E+02
1.600E+02
1.400E+02
1.200E+02
1.000E+02
8.000E+01
6.000E+01
4.000E+01
2.000E+01
0.000E+00
Emissions
1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
1955	0	0	0	0	0	0
1956	1.940E+02	1.553E+05	1.044E+01	5.182E+01	7.767E+04	5.219E+00
1957	3.785E+02	3.031E+05	2.037E+01	1.011E+02	1.516E+05	1.018E+01
1958	5.541E+02	4.437E+05	2.981E+01	1.480E+02	2.218E+05	1.490E+01
1959	7.210E+02	5.774E+05	3.879E+01	1.926E+02	2.887E+05	1.940E+01
1960	8.799E+02	7.046E+05	4.734E+01	2.350E+02	3.523E+05	2.367E+01
1961	1.031E+03	8.255E+05	5.547E+01	2.754E+02	4.128E+05	2.773E+01
1962	1.175E+03	9.406E+05	6.320E+01	3.138E+02	4.703E+05	3.160E+01
1963	1.311E+03	1.050E+06	7.055E+01	3.503E+02	5.250E+05	3.528E+01
1964	1.441E+03	1.154E+06	7.755E+01	3.850E+02	5.771E+05	3.878E+01
1965	1.565E+03	1.253E+06	8.421E+01	4.181E+02	6.266E+05	4.210E+01
1966	1.683E+03	1.347E+06	9.054E+01	4.495E+02	6.737E+05	4.527E+01
1967	1.795E+03	1.437E+06	9.656E+01	4.794E+02	7.186E+05	4.828E+01
1968	1.901E+03	1.522E+06	1.023E+02	5.078E+02	7.612E+05	5.114E+01
1969	2.002E+03	1.603E+06	1.077E+02	5.349E+02	8.017E+05	5.387E+01
1970	2.099E+03	1.681E+06	1.129E+02	5.606E+02	8.403E+05	5.646E+01
1971	2.190E+03	1.754E+06	1.178E+02	5.851E+02	8.770E+05	5.892E+01
1972	2.278E+03	1.824E+06	1.225E+02	6.084E+02	9.119E+05	6.127E+01
1973	2.360E+03	1.890E+06	1.270E+02	6.305E+02	9.451E+05	6.350E+01
1974	2.439E+03	1.953E+06	1.312E+02	6.516E+02	9.767E+05	6.562E+01
1975	2.514E+03	2.013E+06	1.353E+02	6.716E+02	1.007E+06	6.764E+01
1976	2.586E+03	2.071E+06	1.391E+02	6.907E+02	1.035E+06	6.956E+01
1977	2.654E+03	2.125E+06	1.428E+02	7.088E+02	1.062E+06	7.139E+01
1978	2.718E+03	2.177E+06	1.462E+02	7.261E+02	1.088E+06	7.312E+01
1979	2.780E+03	2.226E+06	1.496E+02	7.425E+02	1.113E+06	7.478E+01
1980	2.838E+03	2.273E+06	1.527E+02	7.581E+02	1.136E+06	7.635E+01
1981	2.894E+03	2.317E+06	1.557E+02	7.729E+02	1.159E+06	7.784E+01
1982	2.947E+03	2.359E+06	1.585E+02	7.870E+02	1.180E+06	7.926E+01
1983	2.803E+03	2.244E+06	1.508E+02	7.487E+02	1.122E+06	7.540E+01
1984	2.666E+03	2.135E+06	1.434E+02	7.121E+02	1.067E+06	7.172E+01
1985	2.536E+03	2.031E+06	1.364E+02	6.774E+02	1.015E+06	6.822E+01
1986	2.412E+03	1.932E+06	1.298E+02	6.444E+02	9.659E+05	6.490E+01
1987	2.295E+03	1.838E+06	1.235E+02	6.130E+02	9.188E+05	6.173E+01
1988	2.183E+03	1.748E+06	1.174E+02	5.831E+02	8.740E+05	5.872E+01
1989	2.076E+03	1.663E+06	1.117E+02	5.546E+02	8.313E+05	5.586E+01
1990	1.975E+03	1.582E+06	1.063E+02	5.276E+02	7.908E+05	5.313E+01
1991	1.879E+03	1.504E+06	1.011E+02	5.018E+02	7.522E+05	5.054E+01
1992	1.787E+03	1.431E+06	9.615E+01	4.774E+02	7.155E+05	4.808E+01
1993	1.700E+03	1.361E+06	9.146E+01	4.541E+02	6.806E+05	4.573E+01
1994	1.617E+03	1.295E+06	8.700E+01	4.319E+02	6.474E+05	4.350E+01
1995	1.538E+03	1.232E+06	8.276E+01	4.109E+02	6.159E+05	4.138E+01
1996	1.463E+03	1.172E+06	7.872E+01	3.908E+02	5.858E+05	3.936E+01
1997	1.392E+03	1.115E+06	7.488E+01	3.718E+02	5.573E+05	3.744E+01
1998	1.324E+03	1.060E+06	7.123E+01	3.536E+02	5.301E+05	3.562E+01
1999	1.259E+03	1.008E+06	6.776E+01	3.364E+02	5.042E+05	3.388E+01
2000	1.198E+03	9.593E+05	6.445E+01	3.200E+02	4.796E+05	3.223E+01
2001	1.140E+03	9.125E+05	6.131E+01	3.044E+02	4.562E+05	3.066E+01
2002	1.084E+03	8.680E+05	5.832E+01	2.895E+02	4.340E+05	2.916E+01
2003	1.031E+03	8.257E+05	5.548E+01	2.754E+02	4.128E+05	2.774E+01
2004	9.808E+02	7.854E+05	5.277E+01	2.620E+02	3.927E+05	2.639E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2005	9.330E+02	7.471E+05	5.020E+01	2.492E+02	3.735E+05	2.510E+01
2006	8.875E+02	7.106E+05	4.775E+01	2.371E+02	3.553E+05	2.387E+01
2007	8.442E+02	6.760E+05	4.542E+01	2.255E+02	3.380E+05	2.271E+01
2008	8.030E+02	6.430E+05	4.320E+01	2.145E+02	3.215E+05	2.160E+01
2009	7.639E+02	6.117E+05	4.110E+01	2.040E+02	3.058E+05	2.055E+01
2010	7.266E+02	5.818E+05	3.909E+01	1.941E+02	2.909E+05	1.955E+01
2011	6.912E+02	5.535E+05	3.719E+01	1.846E+02	2.767E+05	1.859E+01
2012	6.575E+02	5.265E+05	3.537E+01	1.756E+02	2.632E+05	1.769E+01
2013	6.254E+02	5.008E+05	3.365E+01	1.670E+02	2.504E+05	1.682E+01
2014	5.949E+02	4.764E+05	3.201E+01	1.589E+02	2.382E+05	1.600E+01
2015	5.659E+02	4.531E+05	3.045E+01	1.512E+02	2.266E+05	1.522E+01
2016	5.383E+02	4.310E+05	2.896E+01	1.438E+02	2.155E+05	1.448E+01
2017	5.120E+02	4.100E+05	2.755E+01	1.368E+02	2.050E+05	1.377E+01
2018	4.871E+02	3.900E+05	2.620E+01	1.301E+02	1.950E+05	1.310E+01
2019	4.633E+02	3.710E+05	2.493E+01	1.238E+02	1.855E+05	1.246E+01
2020	4.407E+02	3.529E+05	2.371E+01	1.177E+02	1.764E+05	1.186E+01
2021	4.192E+02	3.357E+05	2.255E+01	1.120E+02	1.678E+05	1.128E+01
2022	3.988E+02	3.193E+05	2.145E+01	1.065E+02	1.597E+05	1.073E+01
2023	3.793E+02	3.037E+05	2.041E+01	1.013E+02	1.519E+05	1.020E+01
2024	3.608E+02	2.889E+05	1.941E+01	9.638E+01	1.445E+05	9.707E+00
2025	3.432E+02	2.748E+05	1.847E+01	9.168E+01	1.374E+05	9.233E+00
2026	3.265E+02	2.614E+05	1.757E+01	8.721E+01	1.307E+05	8.783E+00
2027	3.106E+02	2.487E+05	1.671E+01	8.295E+01	1.243E+05	8.354E+00
2028	2.954E+02	2.366E+05	1.589E+01	7.891E+01	1.183E+05	7.947E+00
2029	2.810E+02	2.250E+05	1.512E+01	7.506E+01	1.125E+05	7.559E+00
2030	2.673E+02	2.140E+05	1.438E+01	7.140E+01	1.070E+05	7.191E+00
2031	2.543E+02	2.036E+05	1.368E+01	6.792E+01	1.018E+05	6.840E+00
2032	2.419E+02	1.937E+05	1.301E+01	6.460E+01	9.684E+04	6.506E+00
2033	2.301E+02	1.842E+05	1.238E+01	6.145E+01	9.211E+04	6.189E+00
2034	2.188E+02	1.752E+05	1.177E+01	5.846E+01	8.762E+04	5.887E+00
2035	2.082E+02	1.667E+05	1.120E+01	5.561E+01	8.335E+04	5.600E+00
2036	1.980E+02	1.586E+05	1.065E+01	5.289E+01	7.928E+04	5.327E+00
2037	1.884E+02	1.508E+05	1.013E+01	5.031E+01	7.542E+04	5.067E+00
2038	1.792E+02	1.435E+05	9.640E+00	4.786E+01	7.174E+04	4.820E+00
2039	1.704E+02	1.365E+05	9.170E+00	4.553E+01	6.824E+04	4.585E+00
2040	1.621E+02	1.298E+05	8.723E+00	4.331E+01	6.491E+04	4.361E+00
2041	1.542E+02	1.235E+05	8.297E+00	4.119E+01	6.175E+04	4.149E+00
2042	1.467E+02	1.175E+05	7.893E+00	3.918E+01	5.873E+04	3.946E+00
2043	1.395E+02	1.117E+05	7.508E+00	3.727E+01	5.587E+04	3.754E+00
2044	1.327E+02	1.063E+05	7.142E+00	3.546E+01	5.315E+04	3.571E+00
2045	1.263E+02	1.011E+05	6.793E+00	3.373E+01	5.055E+04	3.397E+00
2046	1.201E+02	9.618E+04	6.462E+00	3.208E+01	4.809E+04	3.231E+00
2047	1.142E+02	9.149E+04	6.147E+00	3.052E+01	4.574E+04	3.073E+00
2048	1.087E+02	8.702E+04	5.847E+00	2.903E+01	4.351E+04	2.924E+00
2049	1.034E+02	8.278E+04	5.562E+00	2.761E+01	4.139E+04	2.781E+00
2050	9.833E+01	7.874E+04	5.291E+00	2.627E+01	3.937E+04	2.645E+00
2051	9.354E+01	7.490E+04	5.033E+00	2.499E+01	3.745E+04	2.516E+00
2052	8.898E+01	7.125E+04	4.787E+00	2.377E+01	3.562E+04	2.394E+00
2053	8.464E+01	6.777E+04	4.554E+00	2.261E+01	3.389E+04	2.277E+00
2054	8.051E+01	6.447E+04	4.332E+00	2.151E+01	3.223E+04	2.166E+00
2055	7.658E+01	6.132E+04	4.120E+00	2.046E+01	3.066E+04	2.060E+00

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2056	7.285E+01	5.833E+04	3.919E+00	1.946E+01	2.917E+04	1.960E+00
2057	6.930E+01	5.549E+04	3.728E+00	1.851E+01	2.774E+04	1.864E+00
2058	6.592E+01	5.278E+04	3.546E+00	1.761E+01	2.639E+04	1.773E+00
2059	6.270E+01	5.021E+04	3.373E+00	1.675E+01	2.510E+04	1.687E+00
2060	5.964E+01	4.776E+04	3.209E+00	1.593E+01	2.388E+04	1.604E+00
2061	5.673E+01	4.543E+04	3.052E+00	1.515E+01	2.272E+04	1.526E+00
2062	5.397E+01	4.321E+04	2.904E+00	1.442E+01	2.161E+04	1.452E+00
2063	5.134E+01	4.111E+04	2.762E+00	1.371E+01	2.055E+04	1.381E+00
2064	4.883E+01	3.910E+04	2.627E+00	1.304E+01	1.955E+04	1.314E+00
2065	4.645E+01	3.720E+04	2.499E+00	1.241E+01	1.860E+04	1.250E+00
2066	4.418E+01	3.538E+04	2.377E+00	1.180E+01	1.769E+04	1.189E+00
2067	4.203E+01	3.366E+04	2.261E+00	1.123E+01	1.683E+04	1.131E+00
2068	3.998E+01	3.201E+04	2.151E+00	1.068E+01	1.601E+04	1.076E+00
2069	3.803E+01	3.045E+04	2.046E+00	1.016E+01	1.523E+04	1.023E+00
2070	3.618E+01	2.897E+04	1.946E+00	9.663E+00	1.448E+04	9.732E-01
2071	3.441E+01	2.755E+04	1.851E+00	9.192E+00	1.378E+04	9.257E-01
2072	3.273E+01	2.621E+04	1.761E+00	8.743E+00	1.311E+04	8.806E-01
2073	3.114E+01	2.493E+04	1.675E+00	8.317E+00	1.247E+04	8.376E-01
2074	2.962E+01	2.372E+04	1.594E+00	7.911E+00	1.186E+04	7.968E-01
2075	2.817E+01	2.256E+04	1.516E+00	7.525E+00	1.128E+04	7.579E-01
2076	2.680E+01	2.146E+04	1.442E+00	7.158E+00	1.073E+04	7.209E-01
2077	2.549E+01	2.041E+04	1.372E+00	6.809E+00	1.021E+04	6.858E-01
2078	2.425E+01	1.942E+04	1.305E+00	6.477E+00	9.709E+03	6.523E-01
2079	2.307E+01	1.847E+04	1.241E+00	6.161E+00	9.235E+03	6.205E-01
2080	2.194E+01	1.757E+04	1.181E+00	5.861E+00	8.785E+03	5.903E-01
2081	2.087E+01	1.671E+04	1.123E+00	5.575E+00	8.356E+03	5.615E-01
2082	1.985E+01	1.590E+04	1.068E+00	5.303E+00	7.949E+03	5.341E-01
2083	1.889E+01	1.512E+04	1.016E+00	5.044E+00	7.561E+03	5.080E-01
2084	1.796E+01	1.438E+04	9.665E-01	4.798E+00	7.192E+03	4.833E-01
2085	1.709E+01	1.368E+04	9.194E-01	4.564E+00	6.842E+03	4.597E-01
2086	1.625E+01	1.302E+04	8.745E-01	4.342E+00	6.508E+03	4.373E-01
2087	1.546E+01	1.238E+04	8.319E-01	4.130E+00	6.191E+03	4.159E-01
2088	1.471E+01	1.178E+04	7.913E-01	3.929E+00	5.889E+03	3.957E-01
2089	1.399E+01	1.120E+04	7.527E-01	3.737E+00	5.601E+03	3.764E-01
2090	1.331E+01	1.066E+04	7.160E-01	3.555E+00	5.328E+03	3.580E-01
2091	1.266E+01	1.014E+04	6.811E-01	3.381E+00	5.068E+03	3.405E-01
2092	1.204E+01	9.642E+03	6.479E-01	3.216E+00	4.821E+03	3.239E-01
2093	1.145E+01	9.172E+03	6.163E-01	3.060E+00	4.586E+03	3.081E-01
2094	1.090E+01	8.725E+03	5.862E-01	2.910E+00	4.362E+03	2.931E-01
2095	1.036E+01	8.299E+03	5.576E-01	2.768E+00	4.150E+03	2.788E-01

Results (Continued)

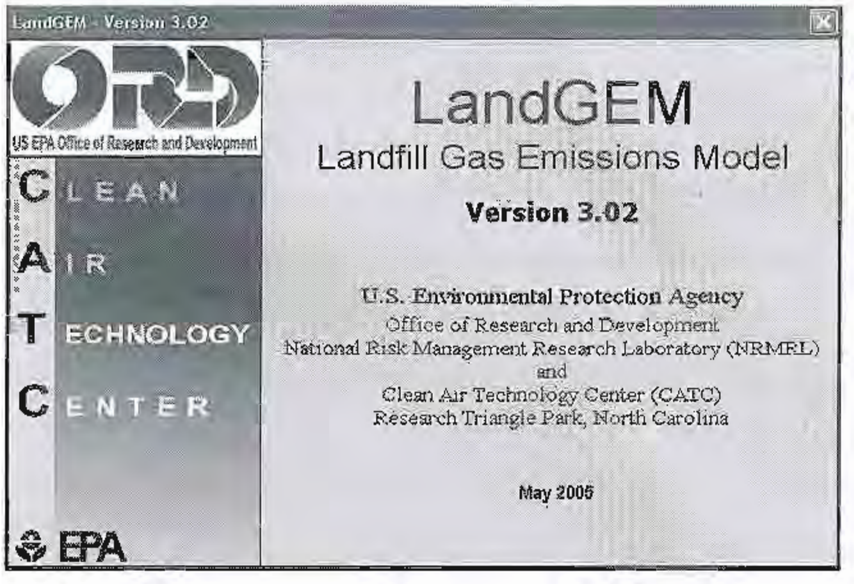
Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1955	0	0	0	0	0	0
1956	1.422E+02	7.767E+04	5.219E+00	3.341E-01	9.320E+01	6.262E-03
1957	2.774E+02	1.516E+05	1.018E+01	6.519E-01	1.819E+02	1.222E-02
1958	4.061E+02	2.218E+05	1.490E+01	9.542E-01	2.662E+02	1.789E-02
1959	5.284E+02	2.887E+05	1.940E+01	1.242E+00	3.464E+02	2.328E-02
1960	6.448E+02	3.523E+05	2.367E+01	1.515E+00	4.227E+02	2.840E-02
1961	7.556E+02	4.128E+05	2.773E+01	1.775E+00	4.953E+02	3.328E-02
1962	8.609E+02	4.703E+05	3.160E+01	2.023E+00	5.644E+02	3.792E-02
1963	9.611E+02	5.250E+05	3.528E+01	2.258E+00	6.300E+02	4.233E-02
1964	1.056E+03	5.771E+05	3.878E+01	2.482E+00	6.925E+02	4.653E-02
1965	1.147E+03	6.266E+05	4.210E+01	2.695E+00	7.520E+02	5.052E-02
1966	1.233E+03	6.737E+05	4.527E+01	2.898E+00	8.085E+02	5.432E-02
1967	1.315E+03	7.186E+05	4.828E+01	3.091E+00	8.623E+02	5.794E-02
1968	1.393E+03	7.612E+05	5.114E+01	3.274E+00	9.134E+02	6.137E-02
1969	1.468E+03	8.017E+05	5.387E+01	3.449E+00	9.621E+02	6.464E-02
1970	1.538E+03	8.403E+05	5.646E+01	3.614E+00	1.008E+03	6.775E-02
1971	1.605E+03	8.770E+05	5.892E+01	3.772E+00	1.052E+03	7.071E-02
1972	1.669E+03	9.119E+05	6.127E+01	3.922E+00	1.094E+03	7.352E-02
1973	1.730E+03	9.451E+05	6.350E+01	4.065E+00	1.134E+03	7.620E-02
1974	1.788E+03	9.767E+05	6.562E+01	4.201E+00	1.172E+03	7.875E-02
1975	1.843E+03	1.007E+06	6.764E+01	4.330E+00	1.208E+03	8.117E-02
1976	1.895E+03	1.035E+06	6.956E+01	4.453E+00	1.242E+03	8.347E-02
1977	1.945E+03	1.062E+06	7.139E+01	4.570E+00	1.275E+03	8.566E-02
1978	1.992E+03	1.088E+06	7.312E+01	4.681E+00	1.306E+03	8.775E-02
1979	2.037E+03	1.113E+06	7.478E+01	4.787E+00	1.335E+03	8.973E-02
1980	2.080E+03	1.136E+06	7.635E+01	4.888E+00	1.364E+03	9.162E-02
1981	2.121E+03	1.159E+06	7.784E+01	4.983E+00	1.390E+03	9.341E-02
1982	2.159E+03	1.180E+06	7.926E+01	5.074E+00	1.416E+03	9.512E-02
1983	2.054E+03	1.122E+06	7.540E+01	4.827E+00	1.347E+03	9.048E-02
1984	1.954E+03	1.067E+06	7.172E+01	4.591E+00	1.281E+03	8.607E-02
1985	1.859E+03	1.015E+06	6.822E+01	4.368E+00	1.218E+03	8.187E-02
1986	1.768E+03	9.659E+05	6.490E+01	4.155E+00	1.159E+03	7.788E-02
1987	1.682E+03	9.188E+05	6.173E+01	3.952E+00	1.103E+03	7.408E-02
1988	1.600E+03	8.740E+05	5.872E+01	3.759E+00	1.049E+03	7.047E-02
1989	1.522E+03	8.313E+05	5.586E+01	3.576E+00	9.976E+02	6.703E-02
1990	1.448E+03	7.908E+05	5.313E+01	3.401E+00	9.489E+02	6.376E-02
1991	1.377E+03	7.522E+05	5.054E+01	3.236E+00	9.027E+02	6.065E-02
1992	1.310E+03	7.155E+05	4.808E+01	3.078E+00	8.586E+02	5.769E-02
1993	1.246E+03	6.806E+05	4.573E+01	2.928E+00	8.168E+02	5.488E-02
1994	1.185E+03	6.474E+05	4.350E+01	2.785E+00	7.769E+02	5.220E-02
1995	1.127E+03	6.159E+05	4.138E+01	2.649E+00	7.390E+02	4.966E-02
1996	1.072E+03	5.858E+05	3.936E+01	2.520E+00	7.030E+02	4.723E-02
1997	1.020E+03	5.573E+05	3.744E+01	2.397E+00	6.687E+02	4.493E-02
1998	9.703E+02	5.301E+05	3.562E+01	2.280E+00	6.361E+02	4.274E-02
1999	9.230E+02	5.042E+05	3.388E+01	2.169E+00	6.051E+02	4.065E-02
2000	8.780E+02	4.796E+05	3.223E+01	2.063E+00	5.756E+02	3.867E-02
2001	8.352E+02	4.562E+05	3.066E+01	1.962E+00	5.475E+02	3.679E-02
2002	7.944E+02	4.340E+05	2.916E+01	1.867E+00	5.208E+02	3.499E-02
2003	7.557E+02	4.128E+05	2.774E+01	1.776E+00	4.954E+02	3.329E-02
2004	7.188E+02	3.927E+05	2.639E+01	1.689E+00	4.712E+02	3.166E-02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2005	6.838E+02	3.735E+05	2.510E+01	1.607E+00	4.482E+02	3.012E-02
2006	6.504E+02	3.553E+05	2.387E+01	1.528E+00	4.264E+02	2.865E-02
2007	6.187E+02	3.380E+05	2.271E+01	1.454E+00	4.056E+02	2.725E-02
2008	5.885E+02	3.215E+05	2.160E+01	1.383E+00	3.858E+02	2.592E-02
2009	5.598E+02	3.058E+05	2.055E+01	1.315E+00	3.670E+02	2.466E-02
2010	5.325E+02	2.909E+05	1.955E+01	1.251E+00	3.491E+02	2.346E-02
2011	5.065E+02	2.767E+05	1.859E+01	1.190E+00	3.321E+02	2.231E-02
2012	4.818E+02	2.632E+05	1.769E+01	1.132E+00	3.159E+02	2.122E-02
2013	4.583E+02	2.504E+05	1.682E+01	1.077E+00	3.005E+02	2.019E-02
2014	4.360E+02	2.382E+05	1.600E+01	1.024E+00	2.858E+02	1.920E-02
2015	4.147E+02	2.266E+05	1.522E+01	9.745E-01	2.719E+02	1.827E-02
2016	3.945E+02	2.155E+05	1.448E+01	9.270E-01	2.586E+02	1.738E-02
2017	3.753E+02	2.050E+05	1.377E+01	8.818E-01	2.460E+02	1.653E-02
2018	3.570E+02	1.950E+05	1.310E+01	8.388E-01	2.340E+02	1.572E-02
2019	3.395E+02	1.855E+05	1.246E+01	7.979E-01	2.226E+02	1.496E-02
2020	3.230E+02	1.764E+05	1.186E+01	7.590E-01	2.117E+02	1.423E-02
2021	3.072E+02	1.678E+05	1.128E+01	7.220E-01	2.014E+02	1.353E-02
2022	2.923E+02	1.597E+05	1.073E+01	6.867E-01	1.916E+02	1.287E-02
2023	2.780E+02	1.519E+05	1.020E+01	6.532E-01	1.822E+02	1.224E-02
2024	2.644E+02	1.445E+05	9.707E+00	6.214E-01	1.734E+02	1.165E-02
2025	2.515E+02	1.374E+05	9.233E+00	5.911E-01	1.649E+02	1.108E-02
2026	2.393E+02	1.307E+05	8.783E+00	5.623E-01	1.569E+02	1.054E-02
2027	2.276E+02	1.243E+05	8.354E+00	5.348E-01	1.492E+02	1.003E-02
2028	2.165E+02	1.183E+05	7.947E+00	5.088E-01	1.419E+02	9.536E-03
2029	2.059E+02	1.125E+05	7.559E+00	4.839E-01	1.350E+02	9.071E-03
2030	1.959E+02	1.070E+05	7.191E+00	4.603E-01	1.284E+02	8.629E-03
2031	1.863E+02	1.018E+05	6.840E+00	4.379E-01	1.222E+02	8.208E-03
2032	1.773E+02	9.684E+04	6.506E+00	4.165E-01	1.162E+02	7.808E-03
2033	1.686E+02	9.211E+04	6.189E+00	3.962E-01	1.105E+02	7.427E-03
2034	1.604E+02	8.762E+04	5.887E+00	3.769E-01	1.051E+02	7.065E-03
2035	1.526E+02	8.335E+04	5.600E+00	3.585E-01	1.000E+02	6.720E-03
2036	1.451E+02	7.928E+04	5.327E+00	3.410E-01	9.514E+01	6.392E-03
2037	1.381E+02	7.542E+04	5.067E+00	3.244E-01	9.050E+01	6.081E-03
2038	1.313E+02	7.174E+04	4.820E+00	3.086E-01	8.609E+01	5.784E-03
2039	1.249E+02	6.824E+04	4.585E+00	2.935E-01	8.189E+01	5.502E-03
2040	1.188E+02	6.491E+04	4.361E+00	2.792E-01	7.789E+01	5.234E-03
2041	1.130E+02	6.175E+04	4.149E+00	2.656E-01	7.410E+01	4.978E-03
2042	1.075E+02	5.873E+04	3.946E+00	2.526E-01	7.048E+01	4.736E-03
2043	1.023E+02	5.587E+04	3.754E+00	2.403E-01	6.704E+01	4.505E-03
2044	9.728E+01	5.315E+04	3.571E+00	2.286E-01	6.377E+01	4.285E-03
2045	9.254E+01	5.055E+04	3.397E+00	2.174E-01	6.066E+01	4.076E-03
2046	8.802E+01	4.809E+04	3.231E+00	2.068E-01	5.771E+01	3.877E-03
2047	8.373E+01	4.574E+04	3.073E+00	1.968E-01	5.489E+01	3.688E-03
2048	7.965E+01	4.351E+04	2.924E+00	1.872E-01	5.221E+01	3.508E-03
2049	7.576E+01	4.139E+04	2.781E+00	1.780E-01	4.967E+01	3.337E-03
2050	7.207E+01	3.937E+04	2.645E+00	1.693E-01	4.725E+01	3.174E-03
2051	6.855E+01	3.745E+04	2.516E+00	1.611E-01	4.494E+01	3.020E-03
2052	6.521E+01	3.562E+04	2.394E+00	1.532E-01	4.275E+01	2.872E-03
2053	6.203E+01	3.389E+04	2.277E+00	1.458E-01	4.066E+01	2.732E-03
2054	5.900E+01	3.223E+04	2.166E+00	1.387E-01	3.868E+01	2.599E-03
2055	5.613E+01	3.066E+04	2.060E+00	1.319E-01	3.679E+01	2.472E-03

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2056	5.339E+01	2.917E+04	1.960E+00	1.255E-01	3.500E+01	2.352E-03
2057	5.079E+01	2.774E+04	1.864E+00	1.193E-01	3.329E+01	2.237E-03
2058	4.831E+01	2.639E+04	1.773E+00	1.135E-01	3.167E+01	2.128E-03
2059	4.595E+01	2.510E+04	1.687E+00	1.080E-01	3.012E+01	2.024E-03
2060	4.371E+01	2.388E+04	1.604E+00	1.027E-01	2.866E+01	1.925E-03
2061	4.158E+01	2.272E+04	1.526E+00	9.771E-02	2.726E+01	1.831E-03
2062	3.955E+01	2.161E+04	1.452E+00	9.294E-02	2.593E+01	1.742E-03
2063	3.762E+01	2.055E+04	1.381E+00	8.841E-02	2.466E+01	1.657E-03
2064	3.579E+01	1.955E+04	1.314E+00	8.410E-02	2.346E+01	1.576E-03
2065	3.404E+01	1.860E+04	1.250E+00	7.999E-02	2.232E+01	1.499E-03
2066	3.238E+01	1.769E+04	1.189E+00	7.609E-02	2.123E+01	1.426E-03
2067	3.080E+01	1.683E+04	1.131E+00	7.238E-02	2.019E+01	1.357E-03
2068	2.930E+01	1.601E+04	1.076E+00	6.885E-02	1.921E+01	1.291E-03
2069	2.787E+01	1.523E+04	1.023E+00	6.549E-02	1.827E+01	1.228E-03
2070	2.651E+01	1.448E+04	9.732E-01	6.230E-02	1.738E+01	1.168E-03
2071	2.522E+01	1.378E+04	9.257E-01	5.926E-02	1.653E+01	1.111E-03
2072	2.399E+01	1.311E+04	8.806E-01	5.637E-02	1.573E+01	1.057E-03
2073	2.282E+01	1.247E+04	8.376E-01	5.362E-02	1.496E+01	1.005E-03
2074	2.171E+01	1.186E+04	7.968E-01	5.101E-02	1.423E+01	9.561E-04
2075	2.065E+01	1.128E+04	7.579E-01	4.852E-02	1.354E+01	9.095E-04
2076	1.964E+01	1.073E+04	7.209E-01	4.615E-02	1.288E+01	8.651E-04
2077	1.868E+01	1.021E+04	6.858E-01	4.390E-02	1.225E+01	8.229E-04
2078	1.777E+01	9.709E+03	6.523E-01	4.176E-02	1.165E+01	7.828E-04
2079	1.691E+01	9.235E+03	6.205E-01	3.972E-02	1.108E+01	7.446E-04
2080	1.608E+01	8.785E+03	5.903E-01	3.779E-02	1.054E+01	7.083E-04
2081	1.530E+01	8.356E+03	5.615E-01	3.594E-02	1.003E+01	6.738E-04
2082	1.455E+01	7.949E+03	5.341E-01	3.419E-02	9.539E+00	6.409E-04
2083	1.384E+01	7.561E+03	5.080E-01	3.252E-02	9.073E+00	6.096E-04
2084	1.317E+01	7.192E+03	4.833E-01	3.094E-02	8.631E+00	5.799E-04
2085	1.252E+01	6.842E+03	4.597E-01	2.943E-02	8.210E+00	5.516E-04
2086	1.191E+01	6.508E+03	4.373E-01	2.799E-02	7.810E+00	5.247E-04
2087	1.133E+01	6.191E+03	4.159E-01	2.663E-02	7.429E+00	4.991E-04
2088	1.078E+01	5.889E+03	3.957E-01	2.533E-02	7.066E+00	4.748E-04
2089	1.025E+01	5.601E+03	3.764E-01	2.409E-02	6.722E+00	4.516E-04
2090	9.753E+00	5.328E+03	3.580E-01	2.292E-02	6.394E+00	4.296E-04
2091	9.278E+00	5.068E+03	3.405E-01	2.180E-02	6.082E+00	4.087E-04
2092	8.825E+00	4.821E+03	3.239E-01	2.074E-02	5.785E+00	3.887E-04
2093	8.395E+00	4.586E+03	3.081E-01	1.973E-02	5.503E+00	3.698E-04
2094	7.985E+00	4.362E+03	2.931E-01	1.876E-02	5.235E+00	3.517E-04
2095	7.596E+00	4.150E+03	2.788E-01	1.785E-02	4.980E+00	3.346E-04



Summary Report

Landfill Name or Identifier: 12th Street Landfill

Date: Tuesday, June 16, 2009

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH_4} = annual methane generation in the year of the calculation *(m^3/year)*

i = 1-year time increment

n = (year of the calculation) - (initial year of waste acceptance)

j = 0.1-year time increment

k = methane generation rate *($year^{-1}$)*

L_o = potential methane generation capacity *(m^3/Mg)*

M_i = mass of waste accepted in the i^{th} year *(Mg)*

t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year *(decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1955**	
Landfill Closure Year (with 80-year limit)	**1982**	
Actual Closure Year (without limit)	***1982***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*year^{-1}*
Potential Methane Generation Capacity, L_o	**179**	*m^3/Mg*
NMOC Concentration	**600**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1955	10,084	11,093	0	0
1956	10,084	11,093	10,084	11,093
1957	10,084	11,093	20,168	22,185
1958	10,084	11,093	30,252	33,278
1959	10,084	11,093	40,336	44,370
1960	10,084	11,093	50,420	55,463
1961	10,084	11,093	60,505	66,555
1962	10,084	11,093	70,589	77,648
1963	10,084	11,093	80,673	88,740
1964	10,084	11,093	90,757	99,833
1965	10,084	11,093	100,841	110,925
1966	10,084	11,093	110,925	122,018
1967	10,084	11,093	121,009	133,110
1968	10,084	11,093	131,093	144,203
1969	10,084	11,093	141,177	155,295
1970	10,084	11,093	151,261	166,388
1971	10,084	11,093	161,345	177,480
1972	10,084	11,093	171,430	188,573
1973	10,084	11,093	181,514	199,665
1974	10,084	11,093	191,598	210,758
1975	10,084	11,093	201,682	221,850
1976	10,084	11,093	211,766	232,943
1977	10,084	11,093	221,850	244,035
1978	10,084	11,093	231,934	255,128
1979	10,084	11,093	242,018	266,220
1980	10,084	11,093	252,102	277,313
1981	10,084	11,093	262,186	288,405
1982	0	0	272,270	299,498
1983	0	0	272,270	299,498
1984	0	0	272,270	299,498
1985	0	0	272,270	299,498
1986	0	0	272,270	299,498
1987	0	0	272,270	299,498
1988	0	0	272,270	299,498
1989	0	0	272,270	299,498
1990	0	0	272,270	299,498
1991	0	0	272,270	299,498
1992	0	0	272,270	299,498
1993	0	0	272,270	299,498
1994	0	0	272,270	299,498

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1995	0	0	272,270	299,498
1996	0	0	272,270	299,498
1997	0	0	272,270	299,498
1998	0	0	272,270	299,498
1999	0	0	272,270	299,498
2000	0	0	272,270	299,498
2001	0	0	272,270	299,498
2002	0	0	272,270	299,498
2003	0	0	272,270	299,498
2004	0	0	272,270	299,498
2005	0	0	272,270	299,498
2006	0	0	272,270	299,498
2007	0	0	272,270	299,498
2008	0	0	272,270	299,498
2009	0	0	272,270	299,498
2010	0	0	272,270	299,498
2011	0	0	272,270	299,498
2012	0	0	272,270	299,498
2013	0	0	272,270	299,498
2014	0	0	272,270	299,498
2015	0	0	272,270	299,498
2016	0	0	272,270	299,498
2017	0	0	272,270	299,498
2018	0	0	272,270	299,498
2019	0	0	272,270	299,498
2020	0	0	272,270	299,498
2021	0	0	272,270	299,498
2022	0	0	272,270	299,498
2023	0	0	272,270	299,498
2024	0	0	272,270	299,498
2025	0	0	272,270	299,498
2026	0	0	272,270	299,498
2027	0	0	272,270	299,498
2028	0	0	272,270	299,498
2029	0	0	272,270	299,498
2030	0	0	272,270	299,498
2031	0	0	272,270	299,498
2032	0	0	272,270	299,498
2033	0	0	272,270	299,498
2034	0	0	272,270	299,498

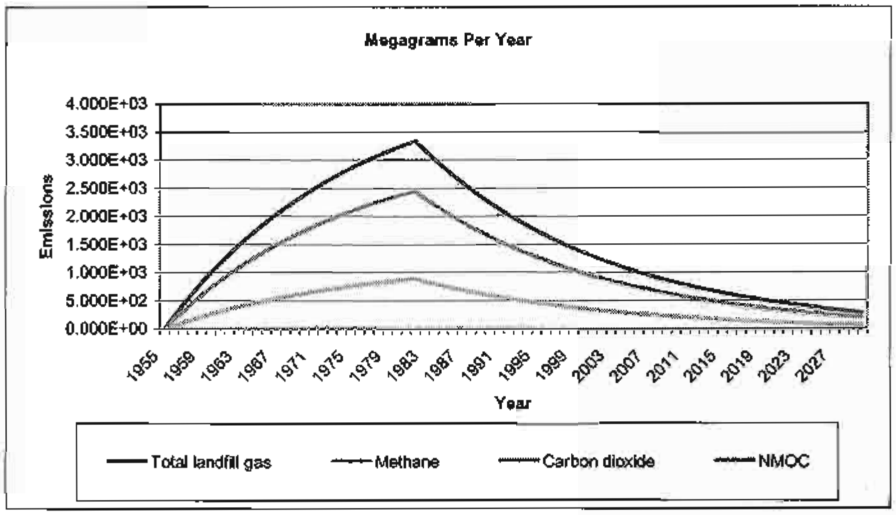
Pollutant Parameters

		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (ppmv)	Molecular Weight	Concentration (ppmv)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			*User-specified Pollutant Parameters:*	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs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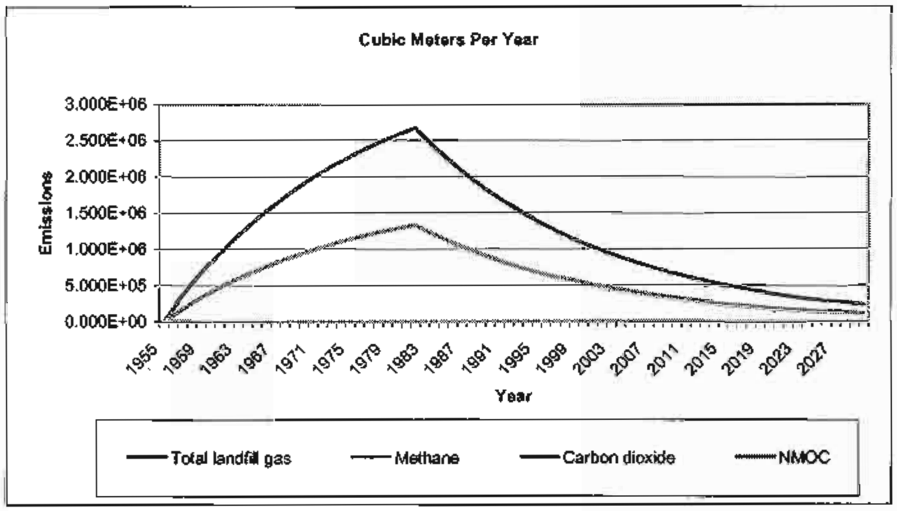
3.000E+03
2.500E+03
2.000E+03
1.500E+03
1.000E+03
5.000E+02
0.000E+00
Emissions
1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
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2.000E+06
1.500E+06
1.000E+06
5.000E+05
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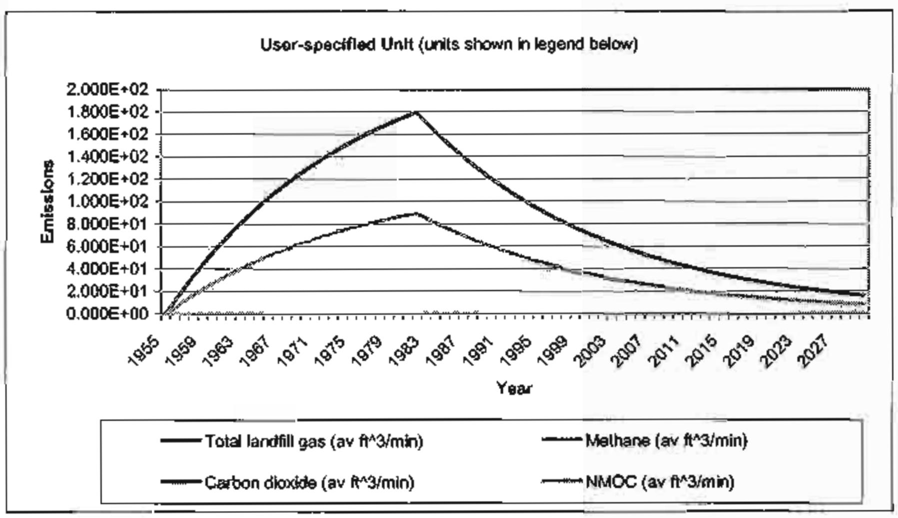
Emissions
1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027
Year
Total landfill gas
Methane
Carbon dioxide
NMOC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1.600E+02
1.400E+02
1.200E+02
1.000E+02
8.000E+01
6.000E+01
4.000E+01
2.000E+01
0.000E+00
Emissions
1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007 2011 2015 2019 2023 2027
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
1955	0	0	0	0	0	0
1956	2.199E+02	1.761E+05	1.183E+01	5.873E+01	8.803E+04	5.915E+00
1957	4.290E+02	3.435E+05	2.308E+01	1.146E+02	1.718E+05	1.154E+01
1958	6.279E+02	5.028E+05	3.378E+01	1.677E+02	2.514E+05	1.689E+01
1959	8.172E+02	6.544E+05	4.397E+01	2.183E+02	3.272E+05	2.198E+01
1960	9.972E+02	7.985E+05	5.365E+01	2.664E+02	3.992E+05	2.683E+01
1961	1.168E+03	9.356E+05	6.286E+01	3.121E+02	4.678E+05	3.143E+01
1962	1.331E+03	1.066E+06	7.163E+01	3.556E+02	5.330E+05	3.581E+01
1963	1.486E+03	1.190E+06	7.996E+01	3.970E+02	5.950E+05	3.998E+01
1964	1.634E+03	1.308E+06	8.789E+01	4.363E+02	6.541E+05	4.395E+01
1965	1.774E+03	1.420E+06	9.543E+01	4.738E+02	7.102E+05	4.772E+01
1966	1.907E+03	1.527E+06	1.026E+02	5.094E+02	7.636E+05	5.130E+01
1967	2.034E+03	1.629E+06	1.094E+02	5.433E+02	8.144E+05	5.472E+01
1968	2.155E+03	1.725E+06	1.159E+02	5.755E+02	8.627E+05	5.796E+01
1969	2.269E+03	1.817E+06	1.221E+02	6.062E+02	9.086E+05	6.105E+01
1970	2.379E+03	1.905E+06	1.280E+02	6.353E+02	9.523E+05	6.399E+01
1971	2.482E+03	1.988E+06	1.336E+02	6.631E+02	9.939E+05	6.678E+01
1972	2.581E+03	2.067E+06	1.389E+02	6.895E+02	1.033E+06	6.944E+01
1973	2.675E+03	2.142E+06	1.439E+02	7.146E+02	1.071E+06	7.197E+01
1974	2.765E+03	2.214E+06	1.487E+02	7.385E+02	1.107E+06	7.437E+01
1975	2.850E+03	2.282E+06	1.533E+02	7.612E+02	1.141E+06	7.666E+01
1976	2.931E+03	2.347E+06	1.577E+02	7.828E+02	1.173E+06	7.883E+01
1977	3.007E+03	2.408E+06	1.618E+02	8.033E+02	1.204E+06	8.090E+01
1978	3.081E+03	2.467E+06	1.657E+02	8.229E+02	1.233E+06	8.287E+01
1979	3.150E+03	2.523E+06	1.695E+02	8.415E+02	1.261E+06	8.475E+01
1980	3.216E+03	2.576E+06	1.731E+02	8.592E+02	1.288E+06	8.653E+01
1981	3.279E+03	2.626E+06	1.764E+02	8.760E+02	1.313E+06	8.822E+01
1982	3.339E+03	2.674E+06	1.797E+02	8.920E+02	1.337E+06	8.983E+01
1983	3.177E+03	2.544E+06	1.709E+02	8.485E+02	1.272E+06	8.545E+01
1984	3.022E+03	2.420E+06	1.626E+02	8.071E+02	1.210E+06	8.128E+01
1985	2.874E+03	2.302E+06	1.546E+02	7.677E+02	1.151E+06	7.732E+01
1986	2.734E+03	2.189E+06	1.471E+02	7.303E+02	1.095E+06	7.355E+01
1987	2.601E+03	2.083E+06	1.399E+02	6.947E+02	1.041E+06	6.996E+01
1988	2.474E+03	1.981E+06	1.331E+02	6.608E+02	9.905E+05	6.655E+01
1989	2.353E+03	1.884E+06	1.266E+02	6.286E+02	9.422E+05	6.330E+01
1990	2.238E+03	1.792E+06	1.204E+02	5.979E+02	8.962E+05	6.022E+01
1991	2.129E+03	1.705E+06	1.146E+02	5.688E+02	8.525E+05	5.728E+01
1992	2.025E+03	1.622E+06	1.090E+02	5.410E+02	8.109E+05	5.449E+01
1993	1.927E+03	1.543E+06	1.037E+02	5.146E+02	7.714E+05	5.183E+01
1994	1.833E+03	1.468E+06	9.860E+01	4.895E+02	7.338E+05	4.930E+01
1995	1.743E+03	1.396E+06	9.379E+01	4.657E+02	6.980E+05	4.690E+01
1996	1.658E+03	1.328E+06	8.922E+01	4.429E+02	6.639E+05	4.461E+01
1997	1.577E+03	1.263E+06	8.487E+01	4.213E+02	6.316E+05	4.243E+01
1998	1.500E+03	1.202E+06	8.073E+01	4.008E+02	6.008E+05	4.036E+01
1999	1.427E+03	1.143E+06	7.679E+01	3.812E+02	5.715E+05	3.840E+01
2000	1.358E+03	1.087E+06	7.305E+01	3.627E+02	5.436E+05	3.652E+01
2001	1.291E+03	1.034E+06	6.948E+01	3.450E+02	5.171E+05	3.474E+01
2002	1.228E+03	9.837E+05	6.610E+01	3.281E+02	4.919E+05	3.305E+01
2003	1.169E+03	9.357E+05	6.287E+01	3.121E+02	4.679E+05	3.144E+01
2004	1.112E+03	8.901E+05	5.981E+01	2.969E+02	4.451E+05	2.990E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2005	1.057E+03	8.467E+05	5.689E+01	2.824E+02	4.233E+05	2.844E+01
2006	1.006E+03	8.054E+05	5.411E+01	2.687E+02	4.027E+05	2.706E+01
2007	9.567E+02	7.661E+05	5.148E+01	2.556E+02	3.831E+05	2.574E+01
2008	9.101E+02	7.288E+05	4.897E+01	2.431E+02	3.644E+05	2.448E+01
2009	8.657E+02	6.932E+05	4.658E+01	2.312E+02	3.466E+05	2.329E+01
2010	8.235E+02	6.594E+05	4.431E+01	2.200E+02	3.297E+05	2.215E+01
2011	7.833E+02	6.272E+05	4.214E+01	2.092E+02	3.136E+05	2.107E+01
2012	7.451E+02	5.967E+05	4.009E+01	1.990E+02	2.983E+05	2.004E+01
2013	7.088E+02	5.676E+05	3.813E+01	1.893E+02	2.838E+05	1.907E+01
2014	6.742E+02	5.399E+05	3.627E+01	1.801E+02	2.699E+05	1.814E+01
2015	6.413E+02	5.135E+05	3.451E+01	1.713E+02	2.568E+05	1.725E+01
2016	6.100E+02	4.885E+05	3.282E+01	1.630E+02	2.442E+05	1.641E+01
2017	5.803E+02	4.647E+05	3.122E+01	1.550E+02	2.323E+05	1.561E+01
2018	5.520E+02	4.420E+05	2.970E+01	1.474E+02	2.210E+05	1.485E+01
2019	5.251E+02	4.205E+05	2.825E+01	1.403E+02	2.102E+05	1.413E+01
2020	4.995E+02	3.999E+05	2.687E+01	1.334E+02	2.000E+05	1.344E+01
2021	4.751E+02	3.804E+05	2.556E+01	1.269E+02	1.902E+05	1.278E+01
2022	4.519E+02	3.619E+05	2.432E+01	1.207E+02	1.809E+05	1.216E+01
2023	4.299E+02	3.442E+05	2.313E+01	1.148E+02	1.721E+05	1.156E+01
2024	4.089E+02	3.275E+05	2.200E+01	1.092E+02	1.637E+05	1.100E+01
2025	3.890E+02	3.115E+05	2.093E+01	1.039E+02	1.557E+05	1.046E+01
2026	3.700E+02	2.963E+05	1.991E+01	9.883E+01	1.481E+05	9.954E+00
2027	3.520E+02	2.818E+05	1.894E+01	9.401E+01	1.409E+05	9.468E+00
2028	3.348E+02	2.681E+05	1.801E+01	8.943E+01	1.340E+05	9.007E+00
2029	3.185E+02	2.550E+05	1.713E+01	8.507E+01	1.275E+05	8.567E+00
2030	3.029E+02	2.426E+05	1.630E+01	8.092E+01	1.213E+05	8.150E+00
2031	2.882E+02	2.308E+05	1.550E+01	7.697E+01	1.154E+05	7.752E+00
2032	2.741E+02	2.195E+05	1.475E+01	7.322E+01	1.097E+05	7.374E+00
2033	2.607E+02	2.088E+05	1.403E+01	6.965E+01	1.044E+05	7.014E+00
2034	2.480E+02	1.986E+05	1.334E+01	6.625E+01	9.930E+04	6.672E+00
2035	2.359E+02	1.889E+05	1.269E+01	6.302E+01	9.446E+04	6.347E+00
2036	2.244E+02	1.797E+05	1.207E+01	5.995E+01	8.985E+04	6.037E+00
2037	2.135E+02	1.709E+05	1.149E+01	5.702E+01	8.547E+04	5.743E+00
2038	2.031E+02	1.626E+05	1.093E+01	5.424E+01	8.130E+04	5.463E+00
2039	1.932E+02	1.547E+05	1.039E+01	5.160E+01	7.734E+04	5.196E+00
2040	1.837E+02	1.471E+05	9.886E+00	4.908E+01	7.357E+04	4.943E+00
2041	1.748E+02	1.400E+05	9.404E+00	4.669E+01	6.998E+04	4.702E+00
2042	1.663E+02	1.331E+05	8.945E+00	4.441E+01	6.657E+04	4.473E+00
2043	1.581E+02	1.266E+05	8.509E+00	4.224E+01	6.332E+04	4.254E+00
2044	1.504E+02	1.205E+05	8.094E+00	4.018E+01	6.023E+04	4.047E+00
2045	1.431E+02	1.146E+05	7.699E+00	3.822E+01	5.729E+04	3.850E+00
2046	1.361E+02	1.090E+05	7.324E+00	3.636E+01	5.450E+04	3.662E+00
2047	1.295E+02	1.037E+05	6.966E+00	3.459E+01	5.184E+04	3.483E+00
2048	1.232E+02	9.863E+04	6.627E+00	3.290E+01	4.931E+04	3.313E+00
2049	1.172E+02	9.382E+04	6.304E+00	3.129E+01	4.691E+04	3.152E+00
2050	1.114E+02	8.924E+04	5.996E+00	2.977E+01	4.462E+04	2.998E+00
2051	1.060E+02	8.489E+04	5.704E+00	2.832E+01	4.244E+04	2.852E+00
2052	1.008E+02	8.075E+04	5.425E+00	2.694E+01	4.037E+04	2.713E+00
2053	9.592E+01	7.681E+04	5.161E+00	2.562E+01	3.841E+04	2.580E+00
2054	9.124E+01	7.306E+04	4.909E+00	2.437E+01	3.653E+04	2.455E+00
2055	8.679E+01	6.950E+04	4.670E+00	2.318E+01	3.475E+04	2.335E+00

Results (Continued)

Year	Total landfill gas (Mg/year)	Total landfill gas (m^3/year)	Total landfill gas (av ft^3/min)	Methane (Mg/year)	Methane (m^3/year)	Methane (av ft^3/min)
2056	8.256E+01	6.611E+04	4.442E+00	2.205E+01	3.306E+04	2.221E+00
2057	7.853E+01	6.289E+04	4.225E+00	2.098E+01	3.144E+04	2.113E+00
2058	7.470E+01	5.982E+04	4.019E+00	1.995E+01	2.991E+04	2.010E+00
2059	7.106E+01	5.690E+04	3.823E+00	1.898E+01	2.845E+04	1.912E+00
2060	6.760E+01	5.413E+04	3.637E+00	1.806E+01	2.706E+04	1.818E+00
2061	6.430E+01	5.149E+04	3.459E+00	1.717E+01	2.574E+04	1.730E+00
2062	6.116E+01	4.898E+04	3.291E+00	1.634E+01	2.449E+04	1.645E+00
2063	5.818E+01	4.659E+04	3.130E+00	1.554E+01	2.329E+04	1.565E+00
2064	5.534E+01	4.432E+04	2.978E+00	1.478E+01	2.216E+04	1.489E+00
2065	5.264E+01	4.215E+04	2.832E+00	1.406E+01	2.108E+04	1.416E+00
2066	5.008E+01	4.010E+04	2.694E+00	1.338E+01	2.005E+04	1.347E+00
2067	4.763E+01	3.814E+04	2.563E+00	1.272E+01	1.907E+04	1.281E+00
2068	4.531E+01	3.628E+04	2.438E+00	1.210E+01	1.814E+04	1.219E+00
2069	4.310E+01	3.451E+04	2.319E+00	1.151E+01	1.726E+04	1.159E+00
2070	4.100E+01	3.283E+04	2.206E+00	1.095E+01	1.641E+04	1.103E+00
2071	3.900E+01	3.123E+04	2.098E+00	1.042E+01	1.561E+04	1.049E+00
2072	3.710E+01	2.971E+04	1.996E+00	9.909E+00	1.485E+04	9.980E-01
2073	3.529E+01	2.826E+04	1.899E+00	9.426E+00	1.413E+04	9.493E-01
2074	3.357E+01	2.688E+04	1.806E+00	8.966E+00	1.344E+04	9.030E-01
2075	3.193E+01	2.557E+04	1.718E+00	8.529E+00	1.278E+04	8.590E-01
2076	3.037E+01	2.432E+04	1.634E+00	8.113E+00	1.216E+04	8.171E-01
2077	2.889E+01	2.313E+04	1.554E+00	7.717E+00	1.157E+04	7.772E-01
2078	2.748E+01	2.201E+04	1.479E+00	7.341E+00	1.100E+04	7.393E-01
2079	2.614E+01	2.093E+04	1.407E+00	6.983E+00	1.047E+04	7.033E-01
2080	2.487E+01	1.991E+04	1.338E+00	6.642E+00	9.956E+03	6.690E-01
2081	2.365E+01	1.894E+04	1.273E+00	6.318E+00	9.471E+03	6.363E-01
2082	2.250E+01	1.802E+04	1.211E+00	6.010E+00	9.009E+03	6.053E-01
2083	2.140E+01	1.714E+04	1.152E+00	5.717E+00	8.569E+03	5.758E-01
2084	2.036E+01	1.630E+04	1.095E+00	5.438E+00	8.151E+03	5.477E-01
2085	1.937E+01	1.551E+04	1.042E+00	5.173E+00	7.754E+03	5.210E-01
2086	1.842E+01	1.475E+04	9.911E-01	4.921E+00	7.376E+03	4.956E-01
2087	1.752E+01	1.403E+04	9.428E-01	4.681E+00	7.016E+03	4.714E-01
2088	1.667E+01	1.335E+04	8.968E-01	4.452E+00	6.674E+03	4.484E-01
2089	1.586E+01	1.270E+04	8.531E-01	4.235E+00	6.348E+03	4.265E-01
2090	1.508E+01	1.208E+04	8.115E-01	4.029E+00	6.039E+03	4.057E-01
2091	1.435E+01	1.149E+04	7.719E-01	3.832E+00	5.744E+03	3.860E-01
2092	1.365E+01	1.093E+04	7.343E-01	3.645E+00	5.464E+03	3.671E-01
2093	1.298E+01	1.040E+04	6.984E-01	3.468E+00	5.198E+03	3.492E-01
2094	1.235E+01	9.888E+03	6.644E-01	3.298E+00	4.944E+03	3.322E-01
2095	1.175E+01	9.406E+03	6.320E-01	3.138E+00	4.703E+03	3.160E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
1955	0	0	0	0	0	0
1956	1.611E+02	8.803E+04	5.915E+00	3.786E-01	1.056E+02	7.097E-03
1957	3.144E+02	1.718E+05	1.154E+01	7.388E-01	2.061E+02	1.385E-02
1958	4.602E+02	2.514E+05	1.689E+01	1.081E+00	3.017E+02	2.027E-02
1959	5.989E+02	3.272E+05	2.198E+01	1.407E+00	3.926E+02	2.638E-02
1960	7.308E+02	3.992E+05	2.683E+01	1.717E+00	4.791E+02	3.219E-02
1961	8.563E+02	4.678E+05	3.143E+01	2.012E+00	5.614E+02	3.772E-02
1962	9.757E+02	5.330E+05	3.581E+01	2.293E+00	6.396E+02	4.298E-02
1963	1.089E+03	5.950E+05	3.998E+01	2.560E+00	7.141E+02	4.798E-02
1964	1.197E+03	6.541E+05	4.395E+01	2.813E+00	7.849E+02	5.273E-02
1965	1.300E+03	7.102E+05	4.772E+01	3.055E+00	8.522E+02	5.726E-02
1966	1.398E+03	7.636E+05	5.130E+01	3.284E+00	9.163E+02	6.157E-02
1967	1.491E+03	8.144E+05	5.472E+01	3.503E+00	9.772E+02	6.566E-02
1968	1.579E+03	8.627E+05	5.796E+01	3.711E+00	1.035E+03	6.956E-02
1969	1.663E+03	9.086E+05	6.105E+01	3.908E+00	1.090E+03	7.326E-02
1970	1.743E+03	9.523E+05	6.399E+01	4.096E+00	1.143E+03	7.678E-02
1971	1.819E+03	9.939E+05	6.678E+01	4.275E+00	1.193E+03	8.014E-02
1972	1.892E+03	1.033E+06	6.944E+01	4.445E+00	1.240E+03	8.333E-02
1973	1.961E+03	1.071E+06	7.197E+01	4.607E+00	1.285E+03	8.636E-02
1974	2.026E+03	1.107E+06	7.437E+01	4.761E+00	1.328E+03	8.925E-02
1975	2.088E+03	1.141E+06	7.666E+01	4.908E+00	1.369E+03	9.199E-02
1976	2.148E+03	1.173E+06	7.883E+01	5.047E+00	1.408E+03	9.460E-02
1977	2.204E+03	1.204E+06	8.090E+01	5.179E+00	1.445E+03	9.709E-02
1978	2.258E+03	1.233E+06	8.287E+01	5.305E+00	1.480E+03	9.945E-02
1979	2.309E+03	1.261E+06	8.475E+01	5.425E+00	1.514E+03	1.017E-01
1980	2.357E+03	1.288E+06	8.653E+01	5.539E+00	1.545E+03	1.038E-01
1981	2.403E+03	1.313E+06	8.822E+01	5.648E+00	1.576E+03	1.059E-01
1982	2.447E+03	1.337E+06	8.983E+01	5.751E+00	1.604E+03	1.078E-01
1983	2.328E+03	1.272E+06	8.545E+01	5.470E+00	1.526E+03	1.025E-01
1984	2.214E+03	1.210E+06	8.128E+01	5.204E+00	1.452E+03	9.754E-02
1985	2.106E+03	1.151E+06	7.732E+01	4.950E+00	1.381E+03	9.278E-02
1986	2.004E+03	1.095E+06	7.355E+01	4.708E+00	1.314E+03	8.826E-02
1987	1.906E+03	1.041E+06	6.996E+01	4.479E+00	1.250E+03	8.395E-02
1988	1.813E+03	9.905E+05	6.655E+01	4.260E+00	1.189E+03	7.986E-02
1989	1.725E+03	9.422E+05	6.330E+01	4.053E+00	1.131E+03	7.597E-02
1990	1.641E+03	8.962E+05	6.022E+01	3.855E+00	1.075E+03	7.226E-02
1991	1.561E+03	8.525E+05	5.728E+01	3.667E+00	1.023E+03	6.874E-02
1992	1.484E+03	8.109E+05	5.449E+01	3.488E+00	9.731E+02	6.538E-02
1993	1.412E+03	7.714E+05	5.183E+01	3.318E+00	9.257E+02	6.220E-02
1994	1.343E+03	7.338E+05	4.930E+01	3.156E+00	8.805E+02	5.916E-02
1995	1.278E+03	6.980E+05	4.690E+01	3.002E+00	8.376E+02	5.628E-02
1996	1.215E+03	6.639E+05	4.461E+01	2.856E+00	7.967E+02	5.353E-02
1997	1.156E+03	6.316E+05	4.243E+01	2.717E+00	7.579E+02	5.092E-02
1998	1.100E+03	6.008E+05	4.036E+01	2.584E+00	7.209E+02	4.844E-02
1999	1.046E+03	5.715E+05	3.840E+01	2.458E+00	6.858E+02	4.608E-02
2000	9.950E+02	5.436E+05	3.652E+01	2.338E+00	6.523E+02	4.383E-02
2001	9.465E+02	5.171E+05	3.474E+01	2.224E+00	6.205E+02	4.169E-02
2002	9.003E+02	4.919E+05	3.305E+01	2.116E+00	5.902E+02	3.966E-02
2003	8.564E+02	4.679E+05	3.144E+01	2.012E+00	5.614E+02	3.772E-02
2004	8.147E+02	4.451E+05	2.990E+01	1.914E+00	5.341E+02	3.588E-02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2005	7.749E+02	4.233E+05	2.844E+01	1.821E+00	5.080E+02	3.413E-02
2006	7.371E+02	4.027E+05	2.706E+01	1.732E+00	4.832E+02	3.247E-02
2007	7.012E+02	3.831E+05	2.574E+01	1.648E+00	4.597E+02	3.089E-02
2008	6.670E+02	3.644E+05	2.448E+01	1.567E+00	4.373E+02	2.938E-02
2009	6.345E+02	3.466E+05	2.329E+01	1.491E+00	4.159E+02	2.795E-02
2010	6.035E+02	3.297E+05	2.215E+01	1.418E+00	3.956E+02	2.658E-02
2011	5.741E+02	3.136E+05	2.107E+01	1.349E+00	3.763E+02	2.529E-02
2012	5.461E+02	2.983E+05	2.004E+01	1.283E+00	3.580E+02	2.405E-02
2013	5.195E+02	2.838E+05	1.907E+01	1.221E+00	3.405E+02	2.288E-02
2014	4.941E+02	2.699E+05	1.814E+01	1.161E+00	3.239E+02	2.176E-02
2015	4.700E+02	2.568E+05	1.725E+01	1.104E+00	3.081E+02	2.070E-02
2016	4.471E+02	2.442E+05	1.641E+01	1.051E+00	2.931E+02	1.969E-02
2017	4.253E+02	2.323E+05	1.561E+01	9.994E-01	2.788E+02	1.873E-02
2018	4.046E+02	2.210E+05	1.485E+01	9.506E-01	2.652E+02	1.782E-02
2019	3.848E+02	2.102E+05	1.413E+01	9.043E-01	2.523E+02	1.695E-02
2020	3.661E+02	2.000E+05	1.344E+01	8.602E-01	2.400E+02	1.612E-02
2021	3.482E+02	1.902E+05	1.278E+01	8.182E-01	2.283E+02	1.534E-02
2022	3.312E+02	1.809E+05	1.216E+01	7.783E-01	2.171E+02	1.459E-02
2023	3.151E+02	1.721E+05	1.156E+01	7.403E-01	2.065E+02	1.388E-02
2024	2.997E+02	1.637E+05	1.100E+01	7.042E-01	1.965E+02	1.320E-02
2025	2.851E+02	1.557E+05	1.046E+01	6.699E-01	1.869E+02	1.256E-02
2026	2.712E+02	1.481E+05	9.954E+00	6.372E-01	1.778E+02	1.194E-02
2027	2.580E+02	1.409E+05	9.468E+00	6.061E-01	1.691E+02	1.136E-02
2028	2.454E+02	1.340E+05	9.007E+00	5.766E-01	1.609E+02	1.081E-02
2029	2.334E+02	1.275E+05	8.567E+00	5.485E-01	1.530E+02	1.028E-02
2030	2.220E+02	1.213E+05	8.150E+00	5.217E-01	1.455E+02	9.779E-03
2031	2.112E+02	1.154E+05	7.752E+00	4.963E-01	1.385E+02	9.302E-03
2032	2.009E+02	1.097E+05	7.374E+00	4.721E-01	1.317E+02	8.849E-03
2033	1.911E+02	1.044E+05	7.014E+00	4.490E-01	1.253E+02	8.417E-03
2034	1.818E+02	9.930E+04	6.672E+00	4.271E-01	1.192E+02	8.007E-03
2035	1.729E+02	9.446E+04	6.347E+00	4.063E-01	1.134E+02	7.616E-03
2036	1.645E+02	8.985E+04	6.037E+00	3.865E-01	1.078E+02	7.245E-03
2037	1.565E+02	8.547E+04	5.743E+00	3.676E-01	1.026E+02	6.891E-03
2038	1.488E+02	8.130E+04	5.463E+00	3.497E-01	9.756E+01	6.555E-03
2039	1.416E+02	7.734E+04	5.196E+00	3.327E-01	9.281E+01	6.236E-03
2040	1.347E+02	7.357E+04	4.943E+00	3.164E-01	8.828E+01	5.932E-03
2041	1.281E+02	6.998E+04	4.702E+00	3.010E-01	8.397E+01	5.642E-03
2042	1.218E+02	6.657E+04	4.473E+00	2.863E-01	7.988E+01	5.367E-03
2043	1.159E+02	6.332E+04	4.254E+00	2.724E-01	7.598E+01	5.105E-03
2044	1.103E+02	6.023E+04	4.047E+00	2.591E-01	7.228E+01	4.856E-03
2045	1.049E+02	5.729E+04	3.850E+00	2.464E-01	6.875E+01	4.619E-03
2046	9.976E+01	5.450E+04	3.662E+00	2.344E-01	6.540E+01	4.394E-03
2047	9.490E+01	5.184E+04	3.483E+00	2.230E-01	6.221E+01	4.180E-03
2048	9.027E+01	4.931E+04	3.313E+00	2.121E-01	5.918E+01	3.976E-03
2049	8.587E+01	4.691E+04	3.152E+00	2.018E-01	5.629E+01	3.782E-03
2050	8.168E+01	4.462E+04	2.998E+00	1.919E-01	5.354E+01	3.598E-03
2051	7.769E+01	4.244E+04	2.852E+00	1.826E-01	5.093E+01	3.422E-03
2052	7.390E+01	4.037E+04	2.713E+00	1.737E-01	4.845E+01	3.255E-03
2053	7.030E+01	3.841E+04	2.580E+00	1.652E-01	4.609E+01	3.097E-03
2054	6.687E+01	3.653E+04	2.455E+00	1.571E-01	4.384E+01	2.946E-03
2055	6.361E+01	3.475E+04	2.335E+00	1.495E-01	4.170E+01	2.802E-03

Results (Continued)

Year	Carbon dioxide (Mg/year)	Carbon dioxide (m^3/year)	Carbon dioxide (av ft^3/min)	NMOC (Mg/year)	NMOC (m^3/year)	NMOC (av ft^3/min)
2056	6.051E+01	3.306E+04	2.221E+00	1.422E-01	3.967E+01	2.665E-03
2057	5.756E+01	3.144E+04	2.113E+00	1.352E-01	3.773E+01	2.535E-03
2058	5.475E+01	2.991E+04	2.010E+00	1.287E-01	3.589E+01	2.412E-03
2059	5.208E+01	2.845E+04	1.912E+00	1.224E-01	3.414E+01	2.294E-03
2060	4.954E+01	2.706E+04	1.818E+00	1.164E-01	3.248E+01	2.182E-03
2061	4.712E+01	2.574E+04	1.730E+00	1.107E-01	3.089E+01	2.076E-03
2062	4.483E+01	2.449E+04	1.645E+00	1.053E-01	2.939E+01	1.974E-03
2063	4.264E+01	2.329E+04	1.565E+00	1.002E-01	2.795E+01	1.878E-03
2064	4.056E+01	2.216E+04	1.489E+00	9.531E-02	2.659E+01	1.787E-03
2065	3.858E+01	2.108E+04	1.416E+00	9.066E-02	2.529E+01	1.699E-03
2066	3.670E+01	2.005E+04	1.347E+00	8.624E-02	2.406E+01	1.617E-03
2067	3.491E+01	1.907E+04	1.281E+00	8.203E-02	2.289E+01	1.538E-03
2068	3.321E+01	1.814E+04	1.219E+00	7.803E-02	2.177E+01	1.463E-03
2069	3.159E+01	1.726E+04	1.159E+00	7.423E-02	2.071E+01	1.391E-03
2070	3.005E+01	1.641E+04	1.103E+00	7.061E-02	1.970E+01	1.324E-03
2071	2.858E+01	1.561E+04	1.049E+00	6.716E-02	1.874E+01	1.259E-03
2072	2.719E+01	1.485E+04	9.980E-01	6.389E-02	1.782E+01	1.198E-03
2073	2.586E+01	1.413E+04	9.493E-01	6.077E-02	1.695E+01	1.139E-03
2074	2.460E+01	1.344E+04	9.030E-01	5.781E-02	1.613E+01	1.084E-03
2075	2.340E+01	1.278E+04	8.590E-01	5.499E-02	1.534E+01	1.031E-03
2076	2.226E+01	1.216E+04	8.171E-01	5.231E-02	1.459E+01	9.805E-04
2077	2.117E+01	1.157E+04	7.772E-01	4.976E-02	1.388E+01	9.327E-04
2078	2.014E+01	1.100E+04	7.393E-01	4.733E-02	1.320E+01	8.872E-04
2079	1.916E+01	1.047E+04	7.033E-01	4.502E-02	1.256E+01	8.439E-04
2080	1.822E+01	9.956E+03	6.690E-01	4.283E-02	1.195E+01	8.027E-04
2081	1.734E+01	9.471E+03	6.363E-01	4.074E-02	1.136E+01	7.636E-04
2082	1.649E+01	9.009E+03	6.053E-01	3.875E-02	1.081E+01	7.264E-04
2083	1.569E+01	8.569E+03	5.758E-01	3.686E-02	1.028E+01	6.909E-04
2084	1.492E+01	8.151E+03	5.477E-01	3.506E-02	9.782E+00	6.572E-04
2085	1.419E+01	7.754E+03	5.210E-01	3.335E-02	9.305E+00	6.252E-04
2086	1.350E+01	7.376E+03	4.956E-01	3.173E-02	8.851E+00	5.947E-04
2087	1.284E+01	7.016E+03	4.714E-01	3.018E-02	8.419E+00	5.657E-04
2088	1.222E+01	6.674E+03	4.484E-01	2.871E-02	8.009E+00	5.381E-04
2089	1.162E+01	6.348E+03	4.265E-01	2.731E-02	7.618E+00	5.119E-04
2090	1.105E+01	6.039E+03	4.057E-01	2.597E-02	7.246E+00	4.869E-04
2091	1.051E+01	5.744E+03	3.860E-01	2.471E-02	6.893E+00	4.631E-04
2092	1.000E+01	5.464E+03	3.671E-01	2.350E-02	6.557E+00	4.406E-04
2093	9.514E+00	5.198E+03	3.492E-01	2.236E-02	6.237E+00	4.191E-04
2094	9.050E+00	4.944E+03	3.322E-01	2.127E-02	5.933E+00	3.986E-04
2095	8.609E+00	4.703E+03	3.160E-01	2.023E-02	5.644E+00	3.792E-04

ATTACHMENT C

EPA METHOD 2E

METHOD 2E - DETERMINATION OF LANDFILL GAS PRODUCTION FLOW RATE

NOTE: This method does not include all of the specifications (*e.g.*, equipment and supplies) and procedures (*e.g.*, sampling and analytical) essential to its performance. Some material is incorporated by reference from other methods in this part. Therefore, to obtain reliable results, persons using this method should also have a thorough knowledge of at least the following additional test methods: Methods 2 and 3C.

1.0 Scope and Application.

1.1 Applicability. This method applies to the measurement of landfill gas (LFG) production flow rate from municipal solid waste landfills and is used to calculate the flow rate of nonmethane organic compounds (NMOC) from landfills.

1.2 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

2.0 Summary of Method.

2.1 Extraction wells are installed either in a cluster of three or at five dispersed locations in the landfill. A blower is used to extract LFG from the landfill. LFG composition, landfill pressures, and orifice pressure differentials from the wells are measured and the landfill gas production flow rate is calculated.

3.0 Definitions. [Reserved]

4.0 Interferences. [Reserved]

5.0 Safety.

5.1 Since this method is complex, only experienced personnel should perform the test. Landfill gas contains methane, therefore explosive mixtures may exist at or near the landfill. It is advisable to take appropriate safety precautions when testing landfills, such as refraining from smoking and installing explosion-proof equipment.

6.0 Equipment and Supplies.

6.1 Well Drilling Rig. Capable of boring a 0.61 m (24 in.) diameter hole into the landfill to a minimum of 75 percent of the landfill depth. The depth of the well shall not extend to the bottom of the landfill or the liquid level.

6.2 Gravel. No fines. Gravel diameter should be appreciably larger than perforations stated in Sections 6.10 and 8.2.

6.3 Bentonite.

6.4 Backfill Material. Clay, soil, and sandy loam have been found to be acceptable.

6.5 Extraction Well Pipe. Minimum diameter of 3 in., constructed of polyvinyl chloride (PVC), high density polyethylene (HDPE), fiberglass, stainless steel, or other suitable nonporous material capable of transporting landfill gas.

6.6 Above Ground Well Assembly. Valve capable of adjusting gas flow, such as a gate, ball, or butterfly valve; sampling ports at the well head and outlet; and a flow measuring device, such as an in-line orifice meter or pitot tube. A schematic of the aboveground well head assembly is shown in Figure 2E-1.

6.7 Cap. Constructed of PVC or HDPE.

6.8 Header Piping. Constructed of PVC or HDPE.

6.9 Auger. Capable of boring a 0.15- to 0.23-m (6- to 9-in.) diameter hole to a depth equal to the top of the perforated section of the extraction well, for pressure probe installation.

6.10 Pressure Probe. Constructed of PVC or stainless steel (316), 0.025-m (1-in.). Schedule 40 pipe. Perforate the bottom two-thirds. A minimum requirement for perforations is slots or holes with an open area equivalent to four 0.006-m (1/4-in.) diameter holes spaced 90° apart every 0.15 m (6 in.).

6.11 Blower and Flare Assembly. Explosion-proof blower, capable of extracting LFG at a flow rate of

8.5 m^3/min (300 ft^3/min), a water knockout, and flare or incinerator.

6.12 Standard Pitot Tube and Differential Pressure Gauge for Flow Rate Calibration with Standard Pitot. Same as Method 2, Sections 6.7 and 6.8.

6.13 Orifice Meter. Orifice plate, pressure tabs, and pressure measuring device to measure the LFG flow rate.

6.14 Barometer. Same as Method 4, Section 6.1.5.

6.15 Differential Pressure Gauge. Water-filled U-tube manometer or equivalent, capable of measuring within 0.02 mm Hg (0.01 in. H_2O), for measuring the pressure of the pressure probes.

7.0 Reagents and Standards. Not Applicable.

8.0 Sample Collection, Preservation, Storage, and Transport.

8.1 Placement of Extraction Wells. The landfill owner or operator may install a single cluster of three extraction wells in a test area or space five equal-volume wells over the landfill. The cluster wells are recommended but may be used only if the composition, age of the refuse, and the landfill depth of the test area can be determined.

8.1.1 Cluster Wells. Consult landfill site records for the age of the refuse, depth, and composition of various sections of the landfill. Select an area near the perimeter of the landfill with a depth equal to or greater than the average depth of the landfill and with the average age of the refuse between 2 and 10 years old. Avoid areas known to contain nondecomposable materials, such as concrete and asbestos. Locate the cluster wells as shown in Figure 2E-2.

8.1.1.1 The age of the refuse in a test area will not be uniform, so calculate a weighted average age of the refuse as shown in Section 12.2.

8.1.2 Equal Volume Wells. Divide the sections of the landfill that are at least 2 years old into five areas representing equal volumes. Locate an extraction well near the center of each area.

8.2 Installation of Extraction Wells. Use a well drilling rig to dig a 0.6 m (24 in.) diameter hole in the landfill to a minimum of 75 percent of the landfill depth, not to extend to the bottom of the landfill or the liquid level. Perforate the bottom two thirds of the extraction well pipe. A minimum requirement for perforations is holes or slots with an open area equivalent to 0.01-m (0.5-in.) diameter holes spaced 90° apart every 0.1 to 0.2 m (4 to 8 in.). Place the extraction well in the center of the hole and backfill with gravel to a level 0.30 m (1 ft) above the perforated section. Add a layer of backfill material 1.2 m (4 ft) thick. Add a layer of bentonite 0.9 m (3 ft) thick, and backfill the remainder of the hole with cover material or material equal in permeability to the existing cover material. The specifications for extraction well installation are shown in Figure 2E-3.

8.3 Pressure Probes. Shallow pressure probes are used in the check for infiltration of air into the landfill, and deep pressure probes are use to determine the radius of influence. Locate pressure probes along three radial arms approximately 120° apart at distances of 3, 15, 30, and 45 m (10, 50, 100, and 150 ft) from the extraction well. The tester has the option of locating additional pressure probes at distances every 15 m (50 feet) beyond 45 m (150 ft). Example placements of probes are shown in Figure 2E-4. The 15-, 30-, and 45-m, (50-, 100-, and 150-ft) probes from each well, and any additional probes located along the three radial arms (deep probes), shall extend to a depth equal to the top of the perforated section of the extraction wells. All other probes (shallow probes) shall extend to a depth equal to half the depth of the deep probes.

8.3.1 Use an auger to dig a hole, 0.15- to 0.23-m (6- to 9-in.) in diameter, for each pressure probe. Perforate the bottom two thirds of the pressure probe. A minimum requirement for perforations is holes or slots with an open area equivalent to four 0.006-m (0.25-in.) diameter holes spaced 90° apart every 0.15 m (6 in.). Place the pressure probe in the center of the hole and backfill with gravel to a level 0.30 m (1 ft) above the perforated section. Add a layer of backfill material at least 1.2 m (4 ft) thick. Add a layer of bentonite at least 0.3 m (1 ft) thick, and backfill the remainder of the hole with cover material or material equal in permeability to the existing cover material. The specifications for pressure probe installation are shown in Figure 2E-5.

8.4 LFG Flow Rate Measurement. Place the flow measurement device, such as an orifice meter, as shown in Figure 2E-1. Attach the wells to the blower and flare assembly. The individual wells may be ducted to a common header so that a single blower, flare assembly, and flow meter may be used. Use the procedures in Section 10.1 to calibrate the flow meter.

8.5 Leak-Check. A leak-check of the above ground system is required for accurate flow rate measurements and for safety. Sample LFG at the well head sample port and at the outlet sample port. Use Method 3C to determine nitrogen (N_2) concentrations. Determine the difference between the well head and outlet N_2 concentrations using the formula in Section 12.3. The system passes the leak-check if the difference is less than 10,000 ppmv.

8.6 Static Testing. Close the control valves on the well heads during static testing. Measure the gauge pressure (P_g) at each deep pressure probe and the barometric pressure (P_{bar}) every 8 hours (hr) for 3 days. Convert the gauge pressure of each deep pressure probe to absolute pressure using the equation in Section 12.4. Record as P_i (initial absolute pressure).

8.6.1 For each probe, average all of the 8-hr deep pressure probe readings (P_i) and record as P_{ia} (average absolute pressure). P_{ia} is used in Section 8.7.5 to determine the maximum radius of influence.

8.6.2 Measure the static flow rate of each well once during static testing.

8.7 Short-Term Testing. The purpose of short-term testing is to determine the maximum vacuum that can be applied to the wells without infiltration of ambient air into the landfill. The short-term testing is performed on one well at a time. Burn all LFG with a flare or incinerator.

8.7.1 Use the blower to extract LFG from a single well at a rate at least twice the static flow rate of the respective well measured in Section 8.6.2. If using a single blower and flare assembly and a common header system, close the control valve on the wells not being measured. Allow 24 hr for the system to stabilize at this flow rate.

8.7.2 Test for infiltration of air into the landfill by measuring the gauge pressures of the shallow pressure probes and using Method 3C to determine the LFG N_2

concentration. If the LFG N_2 concentration is less than 5 percent and all of the shallow probes have a positive gauge pressure, increase the blower vacuum by 3.7 mm Hg (2 in. H_2O), wait 24 hr, and repeat the tests for infiltration. Continue the above steps of increasing blower vacuum by 3.7 mm Hg (2 in. H_2O), waiting 24 hr, and testing for infiltration until the concentration of N_2 exceeds 5 percent or any of the shallow probes have a negative gauge pressure. When this occurs,reduce the blower vacuum to the maximum setting at which the N_2 concentration was less than 5 percent and the gauge pressures of the shallow probes are positive.

8.7.3 At this blower vacuum, measure atmospheric pressure (P_{bar}) every 8 hr for 24 hr, and record the LFG flow rate (Q_s) and the probe gauge pressures (P_f) for all of the probes. Convert the gauge pressures of the deep probes to absolute pressures for each 8-hr reading at Q_s as shown in Section 12.4.

8.7.4 For each probe, average the 8-hr deep pressure probe absolute pressure readings and record as P_{fa} (the final average absolute pressure).

8.7.5 For each probe, compare the initial average pressure (P_{ia}) from Section 8.6.1 to the final average pressure (P_{fa}). Determine the furthermost point from the well head along each radial arm where $P_{fa} \leq P_{ia}$. This distance is the maximum radius of influence (R_m), which is the distance from the well affected by the vacuum. Average these values to determine the average maximum radius of influence (R_{ma}).

8.7.6 Calculate the depth (D_{st}) affected by the extraction well during the short term test as shown in Section 12.6. If the computed value of D_{st} exceeds the depth of the landfill, set D_{st} equal to the landfill depth.

8.7.7 Calculate the void volume (V) for the extraction well as shown in Section 12.7.

8.7.8 Repeat the procedures in Section 8.7 for each well.

8.8 Calculate the total void volume of the test wells (V_v) by summing the void volumes (V) of each well.

8.9 Long-Term Testing. The purpose of long-term testing is to extract two void volumes of LFG from the extraction wells. Use the blower to extract LFG from the wells. If a single blower and flare assembly and common header system are used, open all control valves and set the blower vacuum equal to the highest stabilized blower vacuum demonstrated by any individual well in Section 8.7. Every 8 hr, sample the LFG from the well head sample port, measure the gauge pressures of the shallow pressure probes, the blower vacuum, the LFG flow rate, and use the criteria for infiltration in Section 8.7.2 and Method 3C to test for infiltration. If infiltration is detected, do not reduce the blower vacuum, instead reduce the LFG flow rate from the well by adjusting the control valve on the well head. Adjust each affected well individually. Continue until the equivalent of two total void volumes (V_v) have been extracted, or until $V_t = 2\ V_v$.

8.9.1 Calculate V_t, the total volume of LFG extracted from the wells, as shown in Section 12.8.

8.9.2 Record the final stabilized flow rate as Q_f and the gauge pressure for each deep probe. If, during the long term testing, the flow rate does not stabilize, calculate Q_f by averaging the last 10 recorded flow rates.

8.9.3 For each deep probe, convert each gauge pressure to absolute pressure as in Section 12.4. Average these values and record as P_{sa}. For each probe, compare P_{ia} to P_{sa}. Determine the furthermost point from the well head along each radial arm where $P_{sa} \leq P_{ia}$. This distance is the stabilized radius of influence. Average these values to determine the average stabilized radius of influence (R_{sa}).

8.10 Determine the NMOC mass emission rate using the procedures in Section 12.9 through 12.15.

9.0 Quality Control.

9.1 Miscellaneous Quality Control Measures.

Section	Quality Control Measure	Effect
10.1	LFG flow rate meter calibration	Ensures accurate measurement of LFG flow rate and sample volume

10.0 Calibration and Standardization.

10.1 LFG Flow Rate Meter (Orifice) Calibration Procedure. Locate a standard pitot tube in line with an orifice meter. Use the procedures in Section 8, 12.5, 12.6, and 12.7 of Method 2 to determine the average dry gas volumetric flow rate for at least five flow rates that bracket the expected LFG flow rates, except in Section 8.1, use a standard pitot tube rather than a Type S pitot tube. Method 3C may be used to determine the dry molecular weight. It may be necessary to calibrate more than one orifice meter in order to bracket the LFG flow rates. Construct a calibration curve by plotting the pressure drops across the orifice meter for each flow rate versus the average dry gas volumetric flow rate in m^3/min of the gas.

11.0 Procedures. [Reserved]

12.0 Data Analysis and Calculations.

12.1 Nomenclature.

A = Age of landfill, yr.

A_{avg} = Average age of the refuse tested, yr.

A_i = Age of refuse in the i^{th} fraction, yr.

A_r = Acceptance rate, Mg/yr.

C_{NMOC} = NMOC concentration, ppmv as hexane ($C_{NMOC} = C_t/6$).

C_o = Concentration of N_2 at the outlet, ppmv.

C_t = NMOC concentration, ppmv (carbon equivalent) from Method 25C.

C_w = Concentration of N_2 at the wellhead, ppmv.

D = Depth affected by the test wells, m.

D_{st} = Depth affected by the test wells in the short-term test, m.

e = Base number for natural logarithms (2.718).

f = Fraction of decomposable refuse in the landfill.

f_i = Fraction of the refuse in the i^{th} section.

k = Landfill gas generation constant, yr^{-1}.

L_o = Methane generation potential, m^3/Mg.

L_o' = Revised methane generation potential to account for the amount of nondecomposable material in the landfill, m^3/Mg.

M_i = Mass of refuse in the ith section, Mg.

M_r = Mass of decomposable refuse affected by the test well, Mg.

P_{bar} = Atmospheric pressure, mm Hg.

P_f = Final absolute pressure of the deep pressure probes during short-term testing, mm Hg.

P_{fa} = Average final absolute pressure of the deep pressure probes during short-term testing, mm Hg.

P_{gf} = final gauge pressure of the deep pressure probes, mm Hg.

P_{gi} = Initial gauge pressure of the deep pressure probes, mm Hg.

P_i = Initial absolute pressure of the deep pressure probes during static testing, mm Hg.

P_{ia} = Average initial absolute pressure of the deep pressure probes during static testing, mm Hg.

P_s = Final absolute pressure of the deep pressure probes during long-term testing, mm Hg.

P_{sa} = Average final absolute pressure of the deep pressure probes during long-term testing, mm Hg.

Q_f = Final stabilized flow rate, m^3/min.

Q_i = LFG flow rate measured at orifice meter during the i^{th} interval, m^3/min.

Q_s = Maximum LFG flow rate at each well determined by short-term test, m^3/min.

Q_t = NMOC mass emission rate, m^3/min.

R_m = Maximum radius of influence, m.

R_{ma} = Average maximum radius of influence, m.

R_s = Stabilized radius of influence for an individual well, m.

R_{sa} = Average stabilized radius of influence, m.

t_i = Age of section i, yr.

t_t = Total time of long-term testing, yr.

t_{vi} = Time of the i^{th} interval (usually 8), hr.

V = Void volume of test well, m^3.

V_r = Volume of refuse affected by the test well, m^3.

V_t = Total volume of refuse affected by the long-term testing, m^3.

V_v = Total void volume affected by test wells, m^3.

WD = Well depth, m.

• = Refuse density, Mg/m^3 (Assume 0.64 Mg/m^3 if data are unavailable).

12.2 Use the following equation to calculate a weighted average age of landfill refuse.

$$A_{avg}=\sum_{i=1}^{N} f_i A_i \qquad \textbf{Eq. 2E-1}$$

12.3 Use the following equation to determine the difference in N_2 concentrations (ppmv) at the well head and outlet location.

$$\text{Difference} = C_o - C_w \qquad \textbf{Eq. 2E-2}$$

12.4 Use the following equation to convert the gauge pressure (P_g) of each initial deep pressure probe to absolute pressure (P_i).

$$P_i = P_{bar} + P_{gi} \qquad \textbf{Eq. 2E-3}$$

12.5 Use the following equation to convert the gauge pressures of the deep probes to absolute pressures for each 8-hr reading at Q_s.

$$P_f = P_{bar} + P_{gf} \qquad \textbf{Eq. 2E-4}$$

12.6 Use the following equation to calculate the depth (D_{st}) affected by the extraction well during the short-term test.

$$D_{st} = WD + R_{ma} \qquad \textbf{Eq. 2E-5}$$

12.7 Use the following equation to calculate the void volume for the extraction well (V).

$$V = 0.40 \cdot R_{ma}^2 \, D_{st} \qquad \textbf{Eq. 2E-6}$$

12.8 Use the following equation to calculate V_t, the total volume of LFG extracted from the wells.

$$V_t = \sum_{i=1}^{N} 60 \, Q_i \, t_{vi} \qquad \textbf{Eq. 2E-7}$$

12.9 Use the following equation to calculate the depth affected by the test well. If using cluster wells, use the average depth of the wells for WD. If the value of D is greater than the depth of the landfill, set D equal to the landfill depth.

$$D = WD + R_{sa} \qquad \textbf{Eq. 2E-8}$$

12.10 Use the following equation to calculate the volume of refuse affected by the test well.

$$V_r = R_{sa}^2 \cdot D \qquad \textbf{Eq. 2E-9}$$

12.11 Use the following equation to calculate the mass affected by the test well.

$$M_r = V_r \bullet \qquad \textbf{Eq. 2E-10}$$

12.12 Modify L_O to account for the nondecomposable refuse in the landfill.

$$L_o' = f\ L_o \qquad \textbf{Eq. 2E-11}$$

12.13 In the following equation, solve for k (landfill gas generation constant) by iteration. A suggested procedure is to select a value for k, calculate the left side of the equation, and if not equal to zero, select another value for k. Continue this process until the left hand side of the equation equals zero, ± 0.001.

$$k_e^{-k} A_{avg} - \frac{Q_f}{2\ L_o'\ M_r} = 0 \qquad \textbf{Eq. 2E-12}$$

12.14 Use the following equation to determine landfill NMOC mass emission rate if the yearly acceptance rate of refuse has been consistent (± 10 percent) over the life of the landfill.

$$Q_t = 2\ L_o'\ A_r\ (1 - e^{-kA})\ C_{NMOC}\ (3.595 \times 10^{-9}) \qquad \textbf{Eq. 2E-13}$$

12.15 Use the following equation to determine landfill NMOC mass emission rate if the acceptance rate has not been consistent over the life of the landfill.

$$Q_t = 2\ k\ L_o'\ C_{NMOC}\ (3.595 \times 10^{-9}) \sum_{i=1}^{n} M_i\ e^{-kt_i} \qquad \textbf{Eq. 2E-14}$$

13.0 Method Performance. [Reserved]

14.0 Pollution Prevention. [Reserved]

15.0 Waste Management. [Reserved]

16.0 References.

1. Same as Method 2, Appendix A, 40 CFR Part 60.

2. Emcon Associates, Methane Generation and Recovery from Landfills. Ann Arbor Science, 1982.

3. The Johns Hopkins University, Brown Station Road Landfill Gas Resource Assessment, Volume 1: Field Testing and Gas Recovery Projections. Laurel, Maryland: October 1982.

4. Mandeville and Associates, Procedure Manual for Landfill Gases Emission Testing.

5. Letter and attachments from Briggum, S., Waste Management of North America, to Thorneloe, S., EPA. Response to July 28, 1988 request for additional information. August 18, 1988.

6. Letter and attachments from Briggum, S., Waste Management of North America, to Wyatt, S., EPA. Response to

December 7, 1988 request for additional information.

January 16, 1989.

17.0 Tables, Diagrams, Flowcharts, and Validation Data.

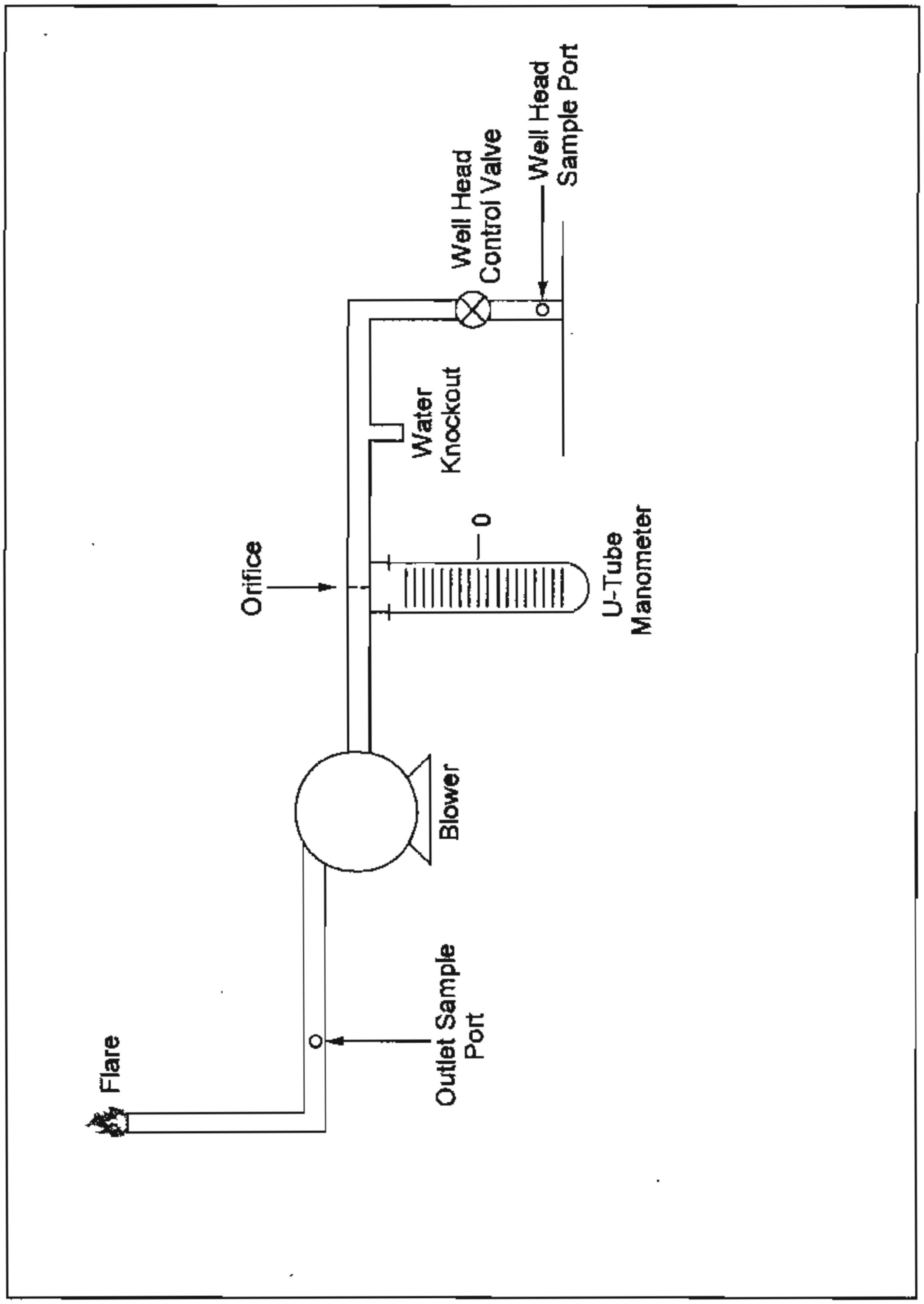

Figure 2E-1. Schematic of Aboveground Well Head Assembly.

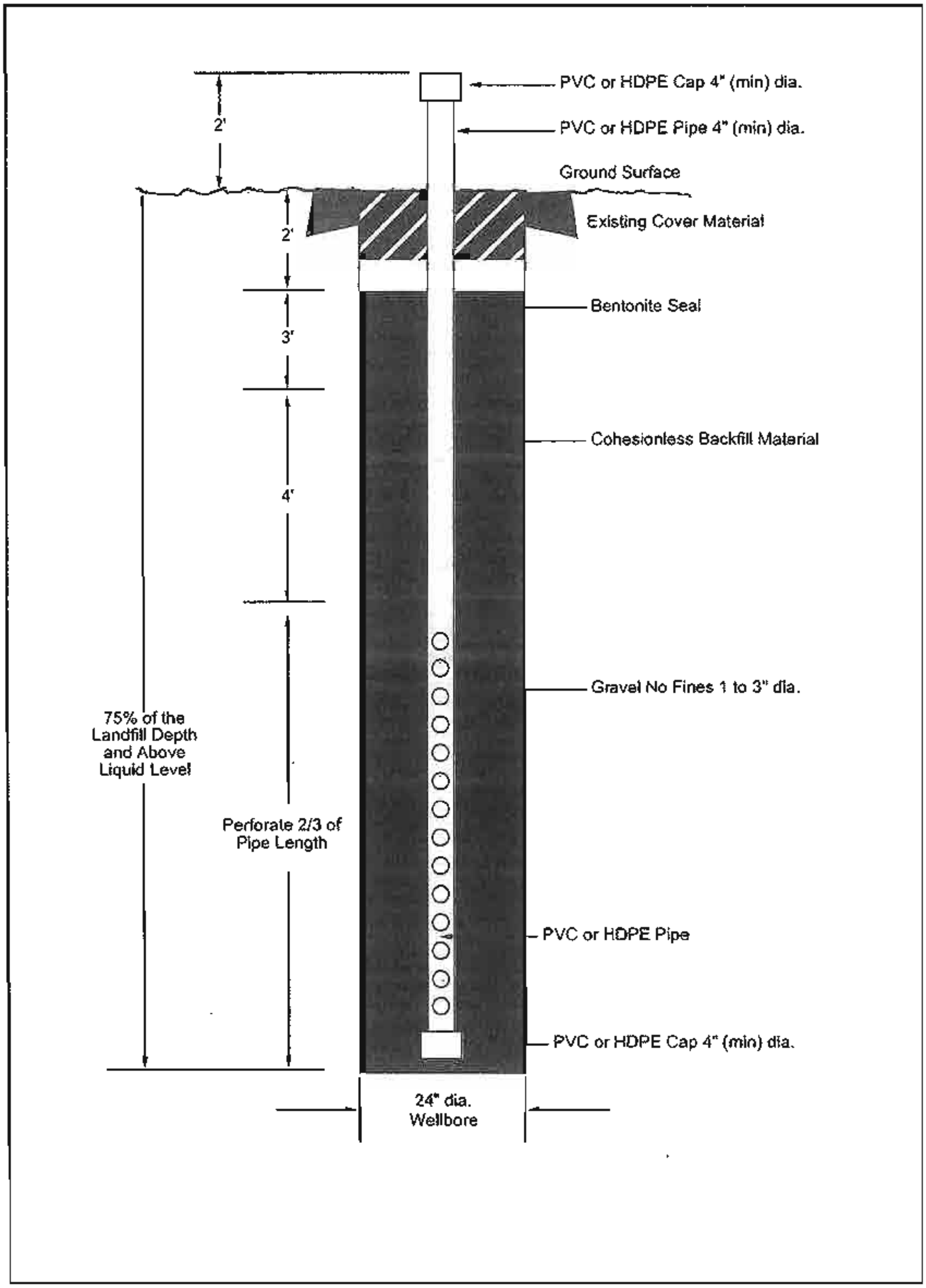

Figure 2E-3. Gas Extraction Well.

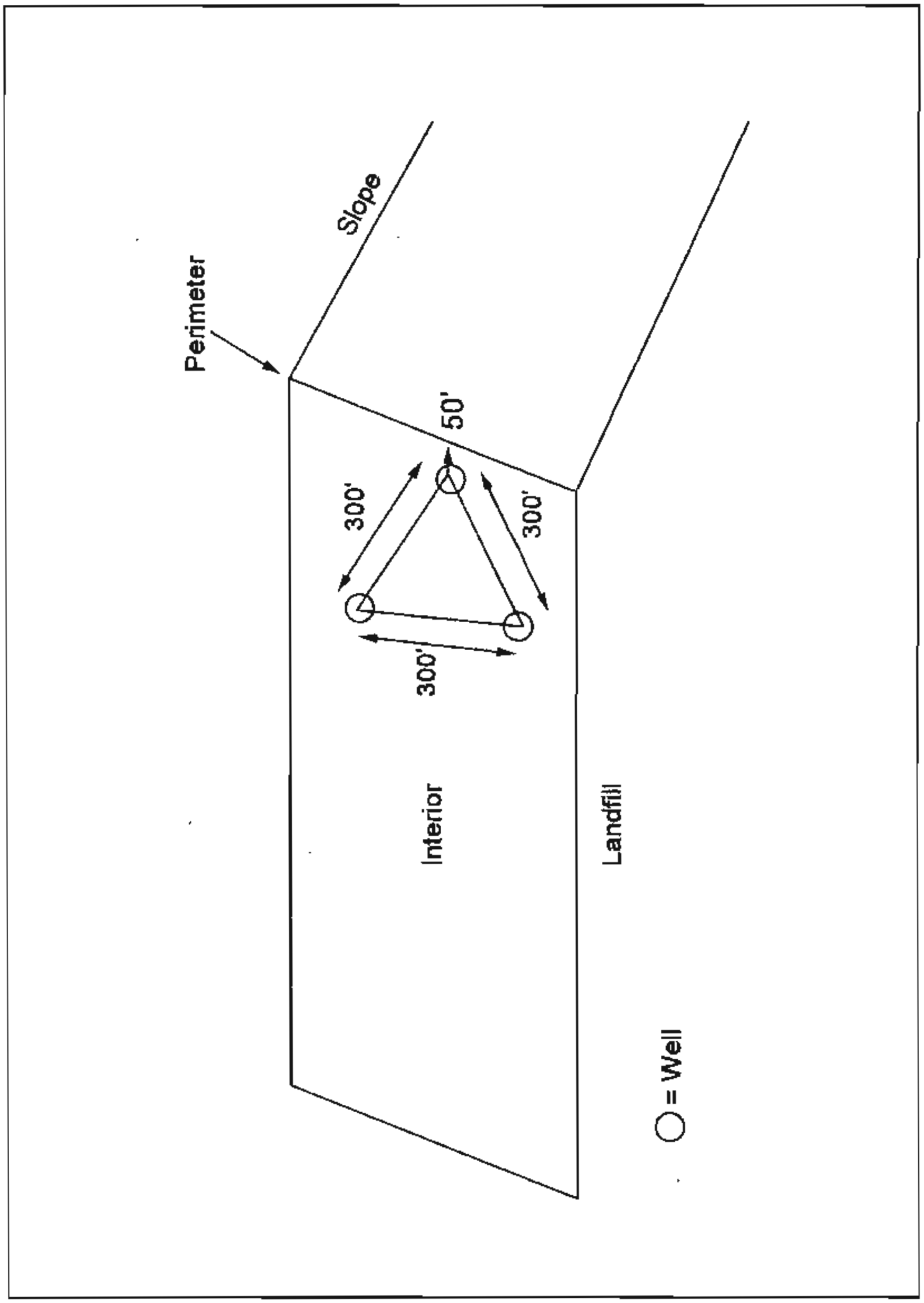

Figure 2E-2. Cluster Well Placement.

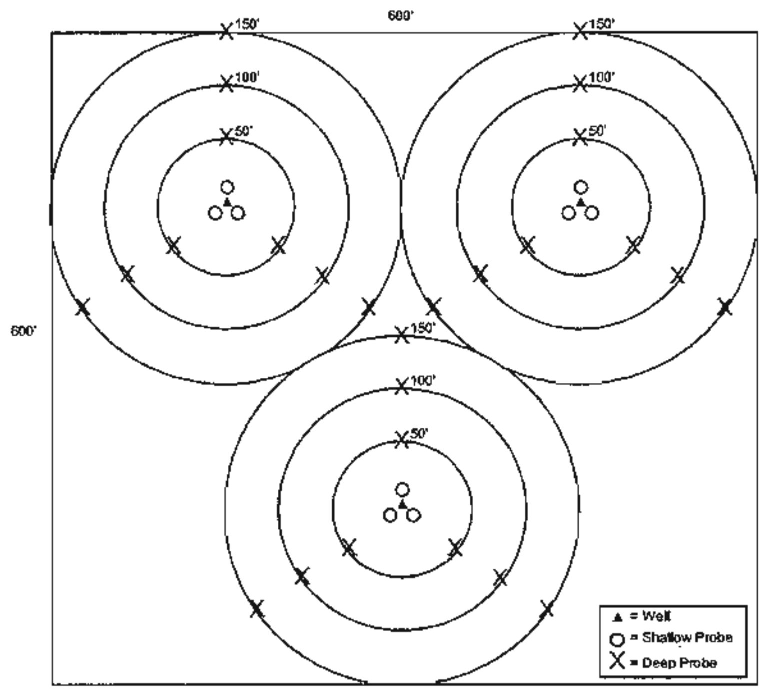

Figure 2E-4. Cluster Well Configuration.

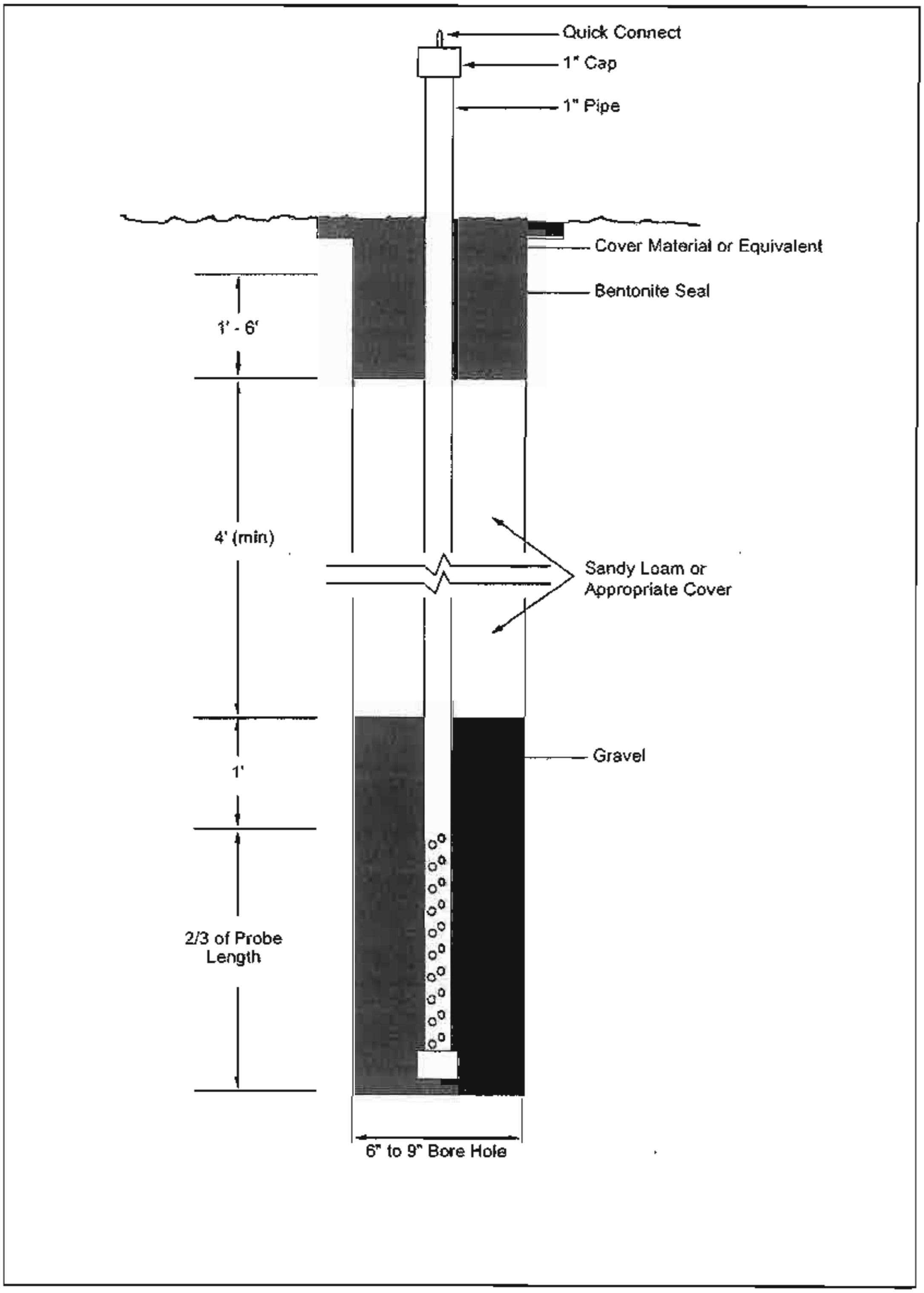

Figure 2E-5. Pressure Probe.

APPENDIX B

SLOPE STABILITY CALCULATIONS

- Replacement for January 2009 Pre-Final Design Report Appendix

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DRAFT MEMO

TO :	Greg Carli / Rick Hoekstra - Conestoga-Rovers & Associates (CRA)	**DATE :**	October 19, 2009
FROM :	Hassan Gilani	**REFERENCE # :**	056393-05-002
SUBJECT :	Slope Stability Evaluation - 12th Street Landfill, Otsego Township, Michigan		

1.0 INTRODUCTION

The 12th Street Landfill (Site) is located in the Otsego Township, Michigan. It is our understanding that it is proposed to excavate approximately 12,000 cubic yards of the surficial paper sludge materials in the surrounding wetland area to the north and the asphalt plant and Michigan Department of Natural Resources (MDNR) property areas to the west and east, respectively, and to place the excavated materials on the existing paper sludge landfill resulting in its vertical expansion. The landfill will be capped after completion of filling operations. A general layout of the existing landfill and adjoining wetlands is shown on Figure 1.

This memorandum provides a summary of the geotechnical evaluation of the stability of the proposed side slopes for the redesigned landfill planned at 3 Horizontal to 1 Vertical (3H:1V) or 4H:1V (design side slopes). The design side slopes will be achieved by cutting back the current side slopes, which are typically around 2H:1V but can be as steep as 1.5H:1V. The geotechnical assessment of the proposed landfill grading plan has been carried out with respect to stability of the planned landfill side slopes, and sliding stability of the proposed cover system. Geotechnical construction recommendations are also provided where effecting the slope and cover system stability.

The geotechnical slope stability evaluations are based on the following documents:

1. Inspec-Sol memo dated June 12, 2009 providing results of the geotechnical investigation, carried out in May 2009, and comprised of 6 sampled landfill boreholes and 12 auger holes in the asphalt plant property (borehole logs attached);
2. RMT Soil Boring Logs RDB-01 to RDB-20 (attached);
3. RMT Test Pit Logs RDTP-01 to RDTP-12 (attached);
4. Geraghty & Miller Inc. geological cross-sections of the Landfill (G&M cross-sections);
5. RMT Pre-Final Design Report dated January 2009 without appendices ;
6. Appendix B 'Slope Stability Calculation' of the RMT Pre-Final Design Report dated 2009 (RMT Appendix B); and
7. Conestoga-Rovers & Associates (CRA) Pre-Final Design Report - Addendum No. 1, Revised Section 6.0 dated May 2009 (CRA Revised Section 6.0 Report).

2.0 BACKGROUND INFORMATION

Based on the RMT Pre-Final Design Report, the 12th Street Landfill was in operation from approximately 1955 to 1981. The paper residuals from the wastewater treatment plant of the nearby former Plainwell Mill were placed into a topographically low area within the current landfill footprint. Prior to placement in the landfill, the wastewater effluent sludge was dewatered 'for several months' in lagoons located at the former Plainwell Mill.

It is understood that the paper sludge residuals transported on to the adjacent areas around the landfill site. The mechanism of the paper sludge transportation has not been discussed in the available documents. Between 1955 and 1967[1], a retaining berm was constructed at the landfill to prevent sludge from the Site entering into the Kalamazoo River. Between 1974 and 1980, the berm was increased in thickness and extended around the entire perimeter of the landfill, except the landfill's southern side. The material used in making the berm is reported to be sand, coal fly ash and paper residuals. In 1984, the 12th Street Landfill was covered with soil and seeded. The landfill ranges in elevation from approximately 702 ft above mean sea level (amsl) near the toe of its northern slope to 734 ft amsl near 12th Street. The existing landfill side slopes are 2H:1V or slightly steeper except along the river's edge where the slope was reconstructed at 5H:1V in 2007. The reconstruction of the eastern side slope was conducted as an Emergency Response Action to prevent any future potential for paper residual transportation to the Kalamazoo River.

A review of the RMT Pre-Final Design Report shows that the depth of the paper sludge residuals to be removed from the adjoining areas can be summarized as follows:

- MDNR Property: 6 to 8 inches in thickness at the ground surface;
- Asphalt Plant Property: about 3.5 ft thick in the northern portion and approximately up to about 10 ft thick in the southern portion; and
- Wetland Areas north of the Landfill: 8 in to 3 ft in thickness covered by a thin layer of topsoil.

3.0 SUMMARIZED SUBSURFACE SOIL AND GROUNDWATER CONDITIONS

3.1 Landfill

Inspec-Sol advanced six soil borings (SB-1 to SB/GW-6) at the locations shown on Figure 1. Two soil borings were instrumented as gas wells (GW). Four soil borings SB/GW-2 to SB-5 were located along the edge of the landfill plateau, and two soil borings, SB-1 and SB/GW-6 were located near the middle of the plateau at the locations shown on Figure 1.

A review of the borehole logs of the soil shows that the landfill is generally covered with a thin topsoil layer. In boreholes, SB-1, SB/GW-2, SB-3, SB-4 and SB-5, generally located along the landfill plateau perimeter, sand (SB-1 to SB-4) and/or paper sludge-fly ash mix (SB-5) materials were encountered at the ground surface or immediately below the surficial topsoil layer, and extend to depths of 9 ft below ground surface (bgs) to 20 ft bgs. The sand/fly ash/paper sludge mix deposits are underlain by paper sludge materials which continue to native sand deposits contacted at depths of 24 ft bgs to 26 ft bgs except SB/GW-2 and SB-5 where the paper residuals continue to the termination depths of the boreholes at 36 ft bgs and 31.5 ft bgs, respectively.

[1] http://www.wmich.edu/env/kalamazooriver/kalriverwatershed.htm

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In boreholes SB-1 and SB/GW-6, advanced close to the north-south centerline of the landfill, the paper sludge materials encountered at or close to the existing ground surface continue to depths of 22 ft bgs and 25.5 ft bgs, respectively, and are underlain by native sand deposits.

Field vane shear tests FVT) were conducted in the paper sludge and paper sludge mixtures and results are summarized in Table 1 (attached) of the previous Inspec-Sol memo dated June 12, 2009. Based on the FVT results, the peak undrained shear strength of the in-situ paper sludge residuals ranged from 516 pounds per square feet (psf) to 3095 psf, with more than half of the values ranging from 1290 psf to 1548 psf. The sensitivity of the paper sludge at the test locations ranged from 1 to 5 indicating that the landfill paper sludge has low to medium sensitivity. Sensitivity is described as ratio of the peak to remolded shear strength, and provides a magnitude of potential reduction in undrained shear strength from its undisturbed (peak) state when remolded (e.g. through excavation).

Brown to light brown native sand deposits encountered at the landfill borehole locations are in a loose to compact state based on the SPT “N” values of 4 to 18.

Laboratory testing comprising moisture content determination and Atterberg Limit analysis on the recovered samples has been summarized in Table 2 (attached) of the previous Inspec-Sol memo dated June 12, 2009. The moisture content of the sand and fly ash berm samples ranged from 5 to 8 percent, and the moisture content of paper sludge and paper sludge mix materials generally ranged from 44 to 126 percent.

Groundwater level measurements were made in the historical monitoring wells LH-1, LH-2 and LH-3 installed in the plateau portion of the landfill at the locations shown on Figure 1. The groundwater level monitoring results are summarized in Table 3 (attached) of the previous Inspec-Sol memo dated June 12, 2009. A review of Table 3 shows that the groundwater near the middle of the landfill is at about 2 to 3 ft below ground surface dropping to about 8.6 ft bgs near the edge of the landfill at LH-3. Groundwater depths were also measured at depths of 18.6 ft bgs and 15.7 ft bgs in the gas wells SB/GW-2 and SB/GW-6, respectively, approximately 24 hours after installation by Inspec-Sol. Gas well SB/GW-2 was found to be dry and groundwater was encountered at a depth of 3.6 ft bgs in SB/GW-6 on June 2, 2009.

3.2 Asphalt Plant Property, MDNR Property, and Wetland Areas

Based on the RMT soil boring and test pit logs and the RMT Pre-Final Design Report, the paper sludge deposits in the MDNR property to the southeast and wetland areas north of the landfill are generally 6 to 8 in thick, with the depth increasing to 2 ft thick at the west end of the wetland areas and are located at the ground surface or are covered by a thin layer (a few inches) of topsoil. The relatively thick deposits in the asphalt plant property (up to 10 ft thick) are overlain/interbedded with sand and/or asphalt layers.

Inspec-Sol advanced twelve (12) auger holes in the southern portion of the asphalt plant property where the deepest paper sludge deposits are located. The purpose of the auger holes was to conduct FVTs to estimate in-situ and remolded undrained shear strength of the paper sludge deposits. The FVT results are summarized in the attached Table 1. A review of Table 1 shows that the peak undrained shear strength of the asphalt plant property samples ranged from 516 psf to 1934 psf with most of the values ranging between 1,032 psf to 1,548 psf. The remolded strength of the paper sludge deposits ranged from 155 psf to 516 psf with most of the values ranging from 258 psf to 516 psf. Based on the FVT results, the sensitivity of the paper sludge residuals was found to range from 2 to 5 with an isolated high

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value of 10 indicating that the asphalt plant property paper sludge materials can be described as low sensitivity to sensitive materials containing zones of extra sensitive materials.

The groundwater in the wetland and MDNR property, as well as the northern portion of the asphalt plant property areas is shallow and is generally at a depth of 1 to 2 ft bgs.

4.0 GLOBAL STABILITY EVALUATION

4.1 General

Global stability refers to the potential of a slope to undergo a relatively deep seated circular failure. The side slopes of the existing landfill constructed at a general gradient of 2H:1V (except the reconstructed slope along the Kalamazoo River) are proposed to be regraded and cut back to 4H:1V or 3H:1V. The eastern side slope along the Kalamazoo River will be maintained at the current gradient of 5H:1V. The slope stability analyses of the proposed landfill side slope configuration have been carried out to evaluate the stability of the planned 3H:1V and 4H:1V slopes.

The following provides a summary of the slope stability evaluation for the landfill.

4.2 Analyses Methodology and Software

The slope stability analyses were performed using the Morgenstern & Price Method using the module Slope/W of the computer software Geo-Studio 2007, Version 7.14, developed and distributed by Geo-Slope International Ltd.

4.3 Cross-Sections Analyzed

Existing and proposed Site contours of the above grade landfill facility are shown on Figure 1 showing contours of the landfill with design side slopes of 3H:1V, and Figure 2 that shows contours with the alternative design side slopes of 4H:1V . Seven cross-sections of the landfill, A-A, A1-A1, B-B, C-C, C1-C1, D-D, E-E and E1-E1 depicting the existing and final closure conditions of the landfill, were selected for static slope stability analyses. The locations of the cross-sections are shown on Figure 1 and Figure 2. The cross-sections were selected based on a combination of subsurface conditions and the above grade landfill slope geometry that would result in representative conditions. The cross-sections were analyzed for the existing and proposed (closure) conditions to determine the relative effect of the proposed vertical expansion on the landfill slopes.

The berm construction history and geometry is not known. For modeling purposes, the interior berm slope was assumed to follow its exterior (existing landfill slope) as also shown on the G&M cross-sections.

The cover system has not been included in the global slope stability analyses and its thickness in the computer models has been conservatively replaced with the new paper sludge materials.

4.4 Material Properties

The properties required for the stability analyses of the slopes are the bulk densities and shear strength parameters of the materials involved. Relevant geotechnical properties comprising bulk density and shear strength of the different subsoil units have been determined from the field investigation, laboratory test results and literature review.

The bulk of the material contained in the existing and the final-closure landfill slopes will be comprised of paper sludge materials, and therefore its properties govern the results of the global stability analyses. Thus, selection of reasonable representative properties for the paper sludge materials is essential for calculating a rational factor of safety for the proposed design side slopes. A literature review, along with the data from the May 2009 geotechnical investigations, was therefore used for selection of paper sludge material parameters.

Paper sludge is typically comprised of kaolinite and organics (wood pulp) and is fibrous in composition. It is also known as fibrous clay in the industry. Kaolinite, a fine clay mineral, is used to provide a smooth surface to the paper. A review of the technical literature summarized on the attached Table 4 shows that paper sludge typically contains approximately 50 percent organics, and is relatively high in shear strength due to its fibrous composition. The Atterberg Limits values summarized on Table 4 show that the liquid limit (LL) of the paper sludge ranged from 255 to 297, the plasticity index (PI) ranged from 77 to 191, and moisture content ranged from 150 to 260 percent. The effective shear strength parameters summarized on Table 4 show that the cohesion intercept (c') can range from 60 psf to 190 psf, and the angle of internal friction (Φ') can range from 25 to 37 degrees. Finally, the literature-based undrained shear strength values range from 250 psf to 1,150 psf, determined through FVT procedure on a paper sludge layer constructed as landfill cover.

A review of the Site-specific laboratory test results summarized in Table 2 of the previous memorandum shows that the organic content of the landfill and adjoining area paper sludge ranges from 9 percent to 22 percent, and the moisture content ranges from 40 percent to 126 percent. These organic content and moisture content values are appreciably lower than the values for relatively fresh paper sludge materials reported in the literature. The lower organic content and moisture content values are indicative of reduction in the organic content through decomposition of the organic content in the landfill sludge materials over a period ranging from 25 to 60 years and/or higher inorganic solid content through mixing with other materials such as fly ash.

The peak undrained shear strength of the landfill paper sludge materials discussed in Section 3.1 and 3.2 is generally 1,000 psf or more and is higher than the literature based undrained shear strength values.

A composite sample of the asphalt plant property paper sludge material was tested for effective shear strength parameters through consolidated drained direct shear test (ASTM D3080). The sample was compacted in the laboratory to a wet density of 93 pounds per cubic feet (pcf) at in-situ moisture content of 73 percent. Based on the test results, the effective shear strength of the composite paper sludge sample is comprised of a cohesion intercept of zero and angle of internal friction of 36 degrees, which compares well with the effective shear strength parameters reported in the literature.

The slope stability analyses have been carried out using the effective shear strength parameters in order to include the effect of the fluctuations in peizometric surface. The effective shear strength parameters for other landfill geometry materials have been deduced from the May 2009 geotechnical investigation and laboratory data, and Inspec-Sol's experience with similar materials. The material properties, including bulk density and effective shear strength parameters, assumed in the slope stability analyses are provided in Table 5. The selected parameters are considered conservative based on the published technical literature and our experience with similar materials.

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4.5 Piezometeric Conditions

Piezometeric surfaces, if passing through the soil mass above the critical slip circle/plane, affect the results significantly. In order to analyze the effect of groundwater conditions on the slope stability, the following groundwater table conditions have been considered.

The first condition used for the analyzing the existing site condition relates to the existing groundwater elevations measured in the historical on-site monitoring wells. The piezometeric line, shown on the slope stability graphs, provided in Appendix A, was developed by interpolating the measured groundwater elevations at the monitoring well locations. Based on the field observations, the piezometeric surface slopes downwards from its high of about 2 to 3 ft below the existing ground surface near the center of the landfill to about 8 ft below the existing ground surface towards the edge of the landfill to the north. The groundwater level in the adjacent off-site areas was encountered at a depth of 1 to 2 feet bgs.

For both the proposed conditions of 3H:1V and 4H:1V side slopes, the piezometric surface was assumed to mound to the ground surface near the center of the landfill sloping downwards generally at the same gradient as for the existing conditions. The paper sludge material generally has a low permeability, as such, mounding of piezometric surface within the landfill is expected in the short-term through generation of excess pore water pressures during vertical expansion of the landfill, and in the long-term if the rate of leachate production exceeds the rate of its drainage. In the adjoining lands, groundwater was assumed at the same depth below the ground surface as for the existing conditions.

4.6 Minimum Factors of Safety

A factor of safety (FS) in slope stability analysis can be defined as the ratio of the available shear strength to that of the applied stresses along a potential failure plane. A factor of safety of 1 or greater indicates stable conditions and a value of less than 1 represent unstable conditions. Although Michigan solid waste regulations do not specify a minimum safety factor, a value of 1.5 was targeted for the static analyses.

4.7 Slope Stability Evaluation Results

The graphical outputs of the slope stability analyses are provided on Figures A1 to A24 in Appendix A, and are summarized in Table 6. A review of the results shows that the targeted minimum factor of safety of 1.5 has been achieved for the proposed 4H:1V and 3H:1V side slopes at all the cross-sections analyzed using the estimated soil shear strength properties. A review of the results shows that the factors of safety for 4H:1V side slope are generally similar to the factors of safety for 3H:1V side slopes; and in a few cases are even lower, indicating that both the slopes are expected to behave similarly during the design life of the landfill. The lower factors of safety can be attributed to the higher excess pore water pressures and additional loads associated with the extra material placed over the existing landfill for the 4H:1V side slops landfill, overcompensating the beneficial effect of the flatter slopes.

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In view of the conservative soil parameters assumed for the analysis and an overall improvement over the existing condition, no significant slope stability issues are anticipated for the side slopes constructed at either 4H:1V or 3H:1V, provided construction recommendations provided in Section 6.0 are followed.

4.8 Effect of Excavation at the Toe of Slope

In order to evaluate the effect of up to 10 ft deep excavation at the toe of the existing landfill on its west side, computer models of Sections A-A and B-B were analyzed by removing 10 ft of existing soils from the toe of the landfill. A review of the slope stability analyses, Figures A25 to A28, provided in Appenidx A shows that factors of safety of 1.06 to 1.4 were obtained which are considered acceptable for the short term conditions, as the excavations will be backfilled as soon as practical. It is further noted that the slope stability models are two-dimensional and therefore are considered conservative as the length of the excavation parallel to the toe of the slopes will be limited to 10 ft as recommended in Section 6.0 of this memorandum.

5.0 COVER SLIDING STABILITY

Based on the Pre-Final Design Report Addendum No. 1 prepared by CRA Revised Section 6.0 Report, the cover system could comprise either of the following two alternatives in a top-to-bottom order:

Cover System Component	***Component Thickness and/or type***	
	Alternative 1	***Alternative 2***
Vegetative Layer	6 inches	6 inches
Protective Layer	General Fill – 12 inches	General Fill – 24 inches
Drainage Layer	Select Granular Fill – 12 inches	Geonet(1)
Separation Layer	12 ounce non-woven geotextile	-
Impermeable Layer	40 mil textured LLDPE	40 mil textured LLDPE
Gas Venting Layer	Geovent	Geovent
Subgrade	Landfill Soils/Paper Sludge	Landfill Soils/Paper Sludge

(1) *The geonet will consist of a plastic grid core sandwiched between two layers of non-woven geotextile.*

The cover system sliding stability analyses were performed using the infinite slope methodology for the critical interfaces between the geosynthetic layers and between geosynthetic layers and landfill soils or cover system soils. The interface shear strength parameters have been assumed based on the literature review and Inspec-Sol's past experience with similar components.

Based on the discussions with CRA, 2 inches of water head has been conservatively assumed to be present in the cover system above the LLDPE layer. At a few locations, due to cutting back of the slopes, the existing paper sludge material behind the berms will be exposed. The existing relatively high content paper sludge material may release pore water at its interface with the cover system, when consolidated under the load of the new paper sludge material. The shear strength parameters at the paper sludge geonet interface and geonet and LLDPE interface will therefore be a function of the rapidity

MEMO (continuous)

with which the excess sludge pore water generated by consolidation process at the interface can be drained.

Undrained/excess pore pressures may create hydrostatic pressure below the cover system causing a reduction in the effective stresses that may lead to cover system sliding/bulging issues. Proper drainage of the paper sludge subgrade or use of relatively free draining and/or drier material is therefore recommended to prevent generation of excess pore water pressures in the cover system subgrade. The high moisture content materials should not be used in the cover system subgrade. Materials with moisture content values higher than 50 percent should be stabilized by using suitable additives prior to their placement in the top 3 ft of the cover subgrade. The moisture content value of 50 percent is selected based on the moisture content results of the paper sludge samples from the boreholes located close to landfill plateau edge.

The interface shear strength parameters used and the results of the analyses are presented in Table 4 and Table 5. The analyses assume no up lift pressures on the cover system. A review of Table 4 and Table 5 shows that for the assumed interface-shear strength parameters and conditions, the calculated factors of safety exceed 1.5 for the 4H:1V and 3H:1V side slopes.

6.0 CONSTRUCTION RECOMMENDATIONS

6.1 Excavation

Prior to commencement of excavation, all vegetation and topsoil must be removed before placing the new paper sludge or cover system on the existing landfill footprint.

All excavations are required to be carried out in accordance with Occupational Safety and Health Administration (OSHA) Regulations, which require that a trench or excavation deeper than 5 ft must be suitably sloped and/or braced in accordance with these regulations.

The OSHA regulations designate four broad categories of rock and soils to stipulate appropriate measures for excavation safety. These categories are stable rock, Type A soil, Type B soil and Type C soil, in decreasing order of strength and stability. OSHA recommends an excavation at 1.5H:1V in soils with low shear strength and soils below the groundwater table. Based on the CRA Pre-Final Design Report Addendum No. 1 report, it is understood that excavations will be carried with side slope inclinations at 4H:1V or flatter.

In the southern portion of the asphalt plant property, excavations in excess of 10 ft in depth may be required at the toe of the existing landfill slopes. At the toe of the landfill slope, narrow trenches, up to 10 ft wide, perpendicular to the strike of the slope face should be excavated to remove the paper sludge materials. The trench must be backfilled before excavating the adjacent trench. Any slope regrading work must commence from toe of an existing slope, toe of a slope must not be cut/undermined, as it may cause slope instability issues.

MEMO (continuous)

6.2 Dewatering

The soils overlying, interbedded and underlying the paper sludge materials in the southern portion of the asphalt plant property are mainly free draining and significant seepage quantities can occur for an excavation extending below the groundwater table (which is not expected to occur at the 12th Street Landfill.

Sump pumping technique may be used for relatively shallow excavations extending to about 2 ft below the ground water level. Due to freely draining soils, sump pumping may be ineffective for the deeper excavations. If the option of sump pumping is used, it must be ensured that the sump pits are lined with suitable geotextile filter fabric held in place with clear stone.

Despite the use of filter cloth, some migration of soil fines may take place with the pump effluent for deeper excavations, loosening the native sand deposits below the landfill slopes which in-turn may cause slope instability problems. It is therefore recommended that positive dewatering systems should be used to dewater deeper excavations. These systems should be designed and installed by a specialty dewatering contractor. The positive dewatering systems must fulfill the following requirements:

- The stability of the sides and bottom of the excavation must be maintained at all times during the construction, and fluctuations in the groundwater table which may cause excavation instability must be avoided;
- Effective filters must be provided to prevent migration of soil fines and subsequent loss of ground;
- Adequate pumping and standby pumping must be provided;
- Pumped water must be discharged such that it will not interfere with the excavation;
- The groundwater table must be maintained at least 2 ft below the base of the progressively rising excavation backfill during its placement, to prevent 'pumping' of the base due to the construction traffic/ compaction effort;
- Adequate monitoring of groundwater levels by observation standpipes must be provided; and
- On completion of construction activities, the dewatering system must be gradually shut down to prevent the creation of transient critical exit gradient conditions, which may result in migration of fines.

6.3 Landfill Expansion

As the excavated paper sludge materials are expected to be relatively high in moisture content, it is therefore recommended that all construction works be carried out in frost-free weather conditions. Prior to commencement of construction, all topsoil (if any) must be removed from the existing landfill.

It is understood that new paper sludge material will not be placed on the proposed side slopes, however if due to the site conditions, if new paper sludge material is required to be placed on the existing landfill slopes, the placement of the new material must be carried out in a stair-step pattern with the compactor moving horizontally instead of up and down the slope. On completion of a particular slope section, the slope can be graded using appropriate equipment.

MEMO (continuous)

The horizontal lift thickness must not exceed 12 inches, with each thickness compacted to at least 95 pcf wet density using a wide-track dozer. In the landfill cover subgrade moisture content of the material should be maintained below 50 percent. Wetter materials must be air-dried before use or stabilized by adding lime/Portland cement or on-site sandy soils. Each lift surface must be scarified to a depth of about 2 inches prior to placing the new lift in order to ensure proper bonding between the lifts.

6.4 Construction Monitoring

The design and construction recommendations provided in this memorandum are based on a limited geotechnical investigation, review of the published data, and estimated landfill material properties. The conditions may vary across the project (on-site and off-site areas) depending on the final design grades and therefore, all critical construction works involving excavation and vertical expansion of the landfill must therefore be carried out under the supervision of a qualified geotechnical engineer to ensure that the actual geotechnical conditions are similar to the estimated conditions. If required, area-specific recommendations can be made on a real-time basis.

7.0 CONCLUSIONS AND RECOMMENDATIONS

1. Based on global slope stability analyses, the proposed 4H:1V or 3H:1V side slopes are considered stable;
2. Excavations at the slope toe must be carried out in up to 10 ft wide trenches perpendicular to the strike of the slope face;
3. Positive dewatering measures must be installed prior to excavations deeper than 2 ft at the toe of the slopes;
4. The new paper sludge material on the side slopes (if required) should be placed in thin horizontal layers and compacted with packing equipment running horizontally, parallel to the face of the slope;
5. Paper sludge layers with moisture contents higher than 50 percent must be stabilized prior to placement and compaction in the cover layer subgrade;
6. The proposed cover systems are considered stable at 4H:1V and 3H:1V provided proper drainage of the paper sludge subgrade is ensured to prevent generation of excess pore water pressures in the cover system subgrade;
7. A geotechnical engineer must monitor all construction works to provide area-specific recommendations on a real-time basis, if required.

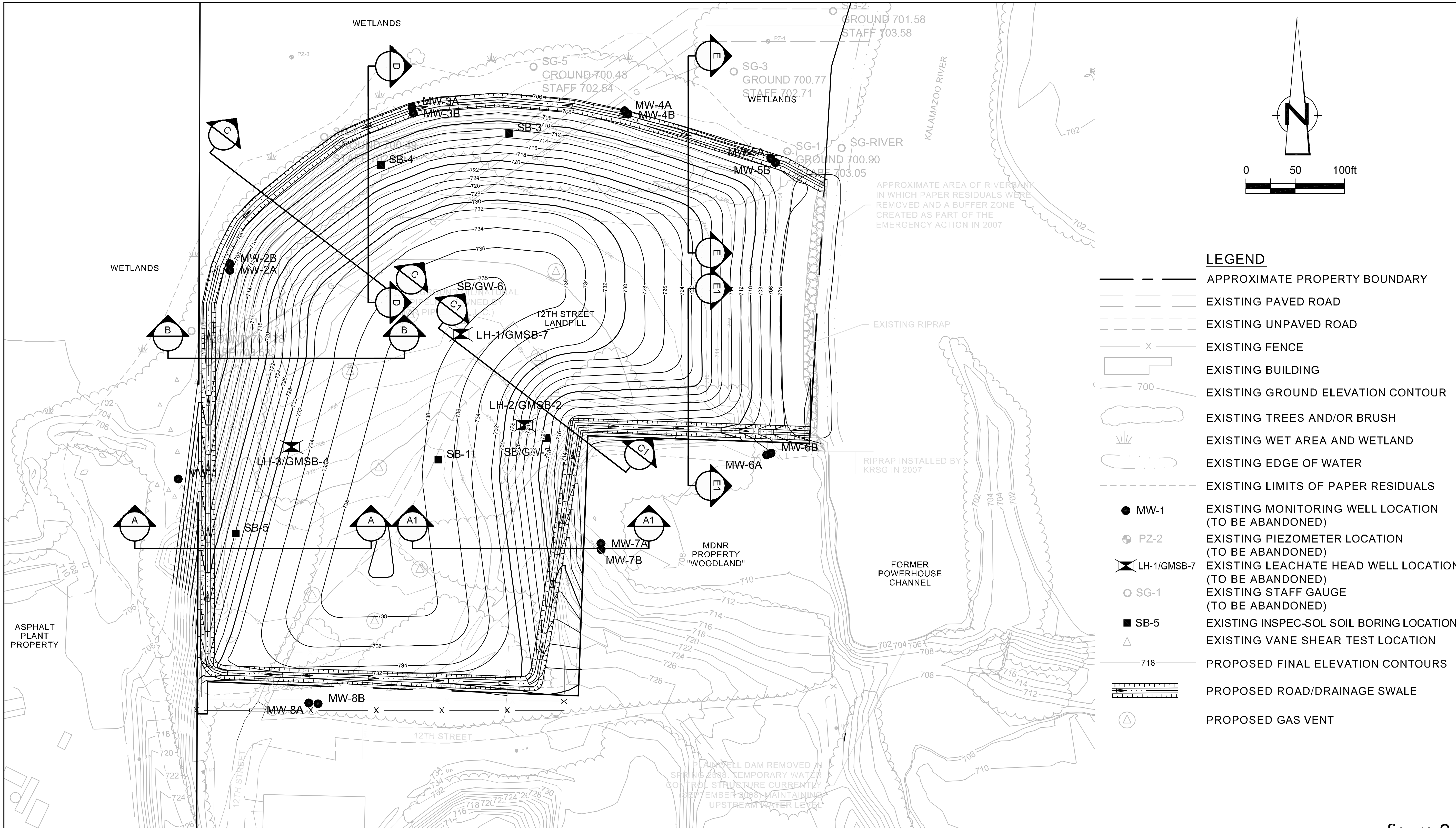

figure 2

SLOPE STABILITY EVALUATION
4:1 SIDE SLOPES
12th STREET LANDFILL
Otsego Township, Michigan

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LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING FENCE
- EXISTING BUILDING
- 700 — EXISTING GROUND ELEVATION CONTOUR
- EXISTING TREES AND/OR BRUSH
- EXISTING WET AREA AND WETLAND
- EXISTING EDGE OF WATER
- EXISTING LIMITS OF PAPER RESIDUALS
- MW-1 — EXISTING MONITORING WELL LOCATION (TO BE ABANDONED)
- PZ-2 — EXISTING PIEZOMETER LOCATION (TO BE ABANDONED)
- LH-1/GMSB-7 — EXISTING LEACHATE HEAD WELL LOCATION (TO BE ABANDONED)
- SG-1 — EXISTING STAFF GAUGE (TO BE ABANDONED)
- SB-5 — EXISTING INSPEC-SOL SOIL BORING LOCATION
- EXISTING VANE SHEAR TEST LOCATION
- 718 — PROPOSED FINAL ELEVATION CONTOURS
- PROPOSED ROAD/DRAINAGE SWALE
- PROPOSED GAS VENT

figure 1

SLOPE STABILITY EVALUATION
3:1 SIDE SLOPES
12th STREET LANDFILL
Otsego Township, Michigan

56393-05(004)GN-WA003 OCT 19/2009

TABLE 1

SUMMARY OF LITERATURE BASED PAPER SLUDGE GEOTECHNICAL PROPERTIES
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Data Source	*Sample Identification*	*Description*	*Moisture Content (%)*	*Wet Unit Weight (lbs/ft^3)*	*Organic Content (%)*	*Specific Gravity*	*Atterberg Limits*			*In-Situ Undrianed Shear Strength*		*Laboratory Effective Shear Strength*		
							Liquid Limit (%)	*Plastic Limit (%)*	*Plasticity Index (%)*	*c_u (psf)*	*Test Method*	*c' (psf)*	*φ' (degrees)*	*Test Method*
Note 1	Sludge A (Test 1)	96% Paper Sludge, 4% Sewage effluent	150 - 250	-	45 - 50	1.88 -1.96	285	94	191	-	-	60	37	CU Triaxial
	Sludge A (Test 2)			-						-	-	190	25	CU Triaxial
	Sludge B	Paper Sludge + Sewgae effluent	200 - 250	-	56	1.83 -1.85	297	147	150	-	-	115	37	CU Triaxial
	Sludge C1	Paper Sludge + wood pulp - 1 week old	255 - 268	-	54 - 56	1.80 -1.85	-	-	-	-	-	-	-	
	Sludge C2	Paper Sludge + wood pulp - 2 to 4 yrs old	180 - 200	-	47 - 49	1.90 -1.93	218	114	104	-	-	-	-	
	Sludge C3	Paper Sludge + wood pulp - 10 to 14 yrs old	220 - 240	-	42 - 46	1.96-1.97	220	143	77	-	-	190	32	CU Triaxial
	Sludge D	wastewater effluent from a Paper Mill, 55% solid content	150 - 200	-	44	1.93-1.95	255	138	117	-	-	115	40	CU Triaxial
	Sludge E	wastewater effluent from a Paper Mill	150 - 200	-	35 - 40	1.96-2.08	-	-	-	-	-	-	-	
Note 2	Montague Landfill Cover		120 - 180	-	-	-	-	-	-	250 - 750	Field Vane	-	-	-
	Hubbardson Landfill Cover		100 - 170	-	-	-	-	-	-	290 - 1150	Field Vane	-	-	-
Note 3	Lagoon 1 (sand/sludge mix)		17.5	117.8		2.62	Non-Plastic			750	Field Vane			
	Lagoon 2		198	76.9		2.26	149	55	94	500	Field Vane			
	Lagoon 3		94	104.5		-	Non-Plastic			500	Field Vane			
Note 4	Landfill Paper Sludge		44 - 126	-	14 & 22	-				500 - 3100	Field Vane			
	Asphalt Plant Sludge		50 - 108	-	12 & 13	-	79	55	24	500 - 1900	Field Vane	0	36	Direct Shear

Note 1: Moo-Young, H.K., Zimmie, T. F. (1996): Geotechnical Properties of Paper Mill Sludges for Use in Landfill Covers
Journal of Geotechnical Engineering, ASCE, Vol 122, No., 9, pp 768-776

Note 2: Quiroz, J. D., Zimmie, T. F. (1999): Field Shear Strength Performance of Two Paper Mill Sludge Landfill Covers
ASTM Committee D18 Symposium 'Geotechnics of High Water Content Materials' January 28-29, 1999, pp 255-266

Note 3: CRA Project No. 30025: Rock-Tenn-Otsego Mill Lagoon Closure

Note 4: CRA Project No. 56393: 12th Street Landfill, Otsego, Geotechnical Investigation - Inspec-Sol Memo dated June 1, 2009.

Hyphen denotes either results not available or test not carried out.

TABLE 2

SHEAR STRENGTH PARAMETERS
SLOPE STABILITY ANALYSES
12th STREET LANDFILL, OTSEGO TOWNSHIP, MICHIGAN

Material	*Unit Weight (lbs/ft^3)*	*Peak Effective Shear Strength Parameters*	
		Cohesion (lbs/ft^2)	*Φ' (Degrees)*
Existing Berm Soils	110	5	30
Existing Paper Sludge	100	50	28
New Paper Sludge	100	50	25
Native Sand	110	0	30
Backfill	110	0	30

Notes:
ϕ denotes angle of internal friction

TABLE 3

SUMMARY OF GLOBAL SLOPE STABILITY ANALYSES
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Loading Condition	***Minimum Calculated Factor of Safety***							
	Section A - A	***Section A1 - A1***	***Section B - B***	***Section C - C***	***Section C1 - C1***	***Section D - D***	***Section E - E***	***Section E1 - E1***
Existing	1.56 Figure A1	1.17 Figure A2	1.06 Figure A3	1.10 Figure A4	1.06 Figure A5	1.49 Figure A6	2.11 Figure A7	1.15 Figure A8
Proposed 3H:1V	1.77 Figure A9	1.68 Figure A10	1.91 Figure A11	1.64 Figure A12	2.36 Figure A13	1.73 Figure A14	1.90 Figure A15	2.09 Figure A16
Proposed 4H:1V	1.75 Figure A17	1.98 Figure A18	1.73 Figure A19	1.69 Figure A20	1.92 Figure A21	1.78 Figure A22	1.73 Figure A23	2.35 Figure A24
Toe Excavation - Existing	1.10 A25	-	1.06 A27	-	-	-	-	-
Toe Excavation - 4H:1V	1.05 A26	-	1.40 A28	-	-	-	-	-

Notes:

Slope stability evaluations performed using Slope/W module of Geo-Studio 2007 developed and distributed by Geo-Slope International Ltd.

TABLE 4

COVER STABILITY ANALYSES
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Critical Interface	*Cover Density γ (lbs/ft^3)*	*Depth to Failure plane z (ft) (Note 1)*	*Depth to Water d_w (ft) (Notes 1, 2)*	*Interface Shear Strength*		*Landfill Slope β*		*Factor of Safety*
				Cohesion c (psf)	*Angle of friction (ϕ)*	*H:V*	*Degrees*	
Vegetative Layer + Protective Layer + Vs 12 Ounce Nonwoven Geotextile	120	2.50	2.46	0	28	3.0 :1	18.4	1.58
12 Ounce nonwoven Geotextile Vs 40 mil textured LLDPE Liner	120	2.50	2.46	0	30	3.0 :1	18.4	1.72
40 mil Textured LLDPE liner Vs nonwoven geotextile (geovent face)	120	2.50	2.50	0	30	3.0 :1	18.4	1.73
Nonwoven geotextile (geovent face) Vs Paper Sludge subgrade	120	2.50	2.50	40	20	3.0 :1	18.4	1.54

$$\text{Factor of Safety (FS)} = \frac{c/(\gamma.z.\cos^2\beta) + \tan\phi\,[1-\gamma_w(z-d_w)/(\gamma.z)] - k_s \tan\beta \tan\phi}{k_s + \tan\beta}$$

γ_w (density of water lb/ft^3) = 62.4

1) Depth to critical surface/water measured vertically from the ground surface.
2) Water depth of 2" assumed over the geonet.
3) The calculated factors of safety are based on assumed interface friction values from published technical-literature, and must be confirmed by Site-specific laboratory testing.

TABLE 5

COVER STABILITY ANALYSES
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Critical Interface	*Cover Density* γ *(lbs/ft³)*	*Depth to Failure plane z (ft) (Note 1)*	*Depth to Water* d_w *(ft) (Notes 1, 2)*	*Interface Shear Strength*		*Landfill Slope* β		*Factor of Safety*
				Cohesion c (psf)	*Angle of friction (* ϕ *)*	*H:V*	*Degrees*	
Vegetative Layer + Protective Layer + Vs 12 Ounce Nonwoven Geotextile	120	2.50	2.46	0	28	4.0 :1	14.0	2.11
12 Ounce nonwoven Geotextile Vs 40 mil textured LLDPE Liner	120	2.50	2.46	0	30	4.0 :1	14.0	2.29
40 mil Textured LLDPE liner Vs nonwoven geotextile (geovent face)	120	2.50	2.50	0	30	4.0 :1	14.0	2.31
Nonwoven geotextile (geovent face) Vs Paper Sludge subgrade	120	2.50	2.50	40	20	4.0 :1	14.0	2.02

$$\text{Factor of Safety (FS)} = \frac{c/(\gamma.z.\cos^2\beta) + \tan\phi\,[1-\gamma_w(z-d_w)/(\gamma.z)] - k_s \tan\beta \tan\phi}{k_s + \tan\beta}$$

γ_w (density of water lb/ft^3) = 62.4

1) Depth to critical surface/water measured vertically from the ground surface.
2) Water depth of 2" assumed over the geonet.
3) The calculated factors of safety are based on assumed interface friction values from published technical-literature, and must be confirmed by Site-specific laboratory testing.

Figure A1
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

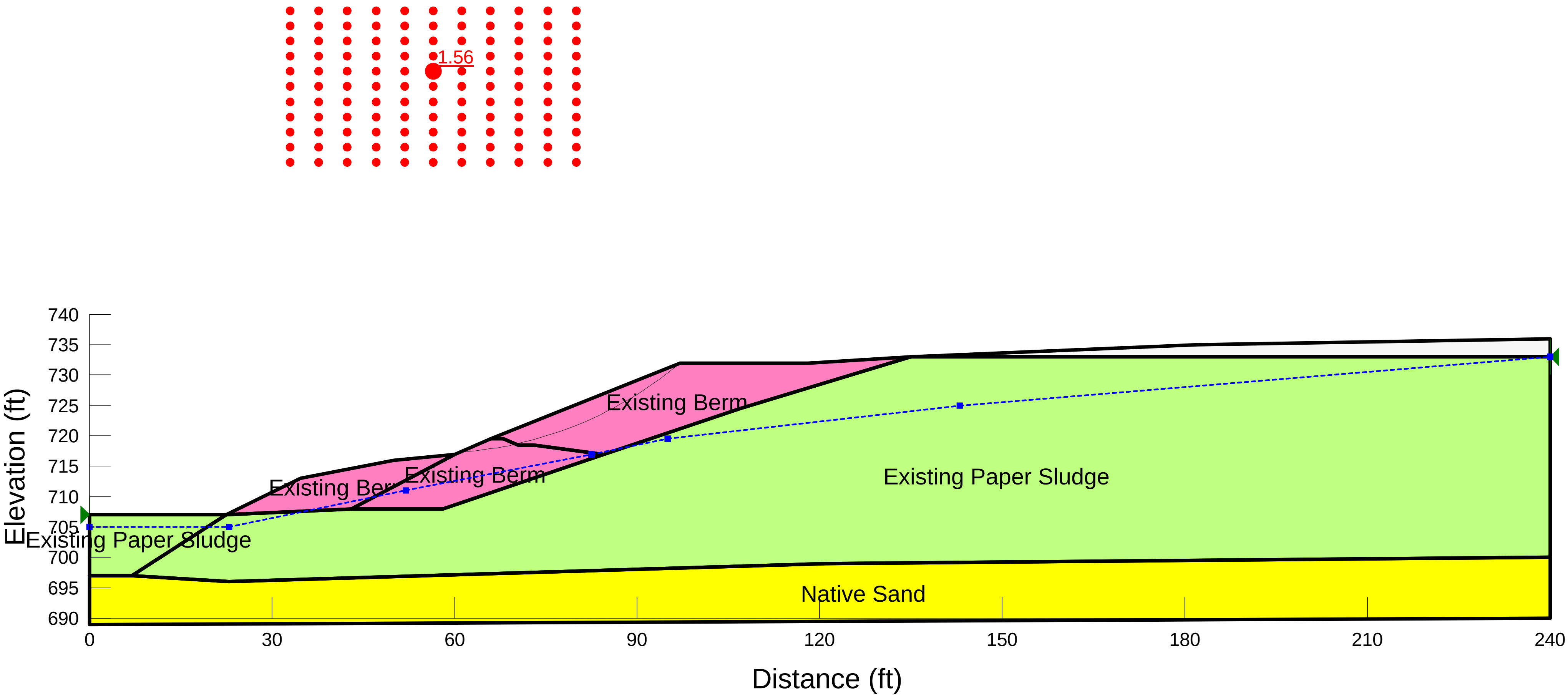


Figure A2
Section A1-A1
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

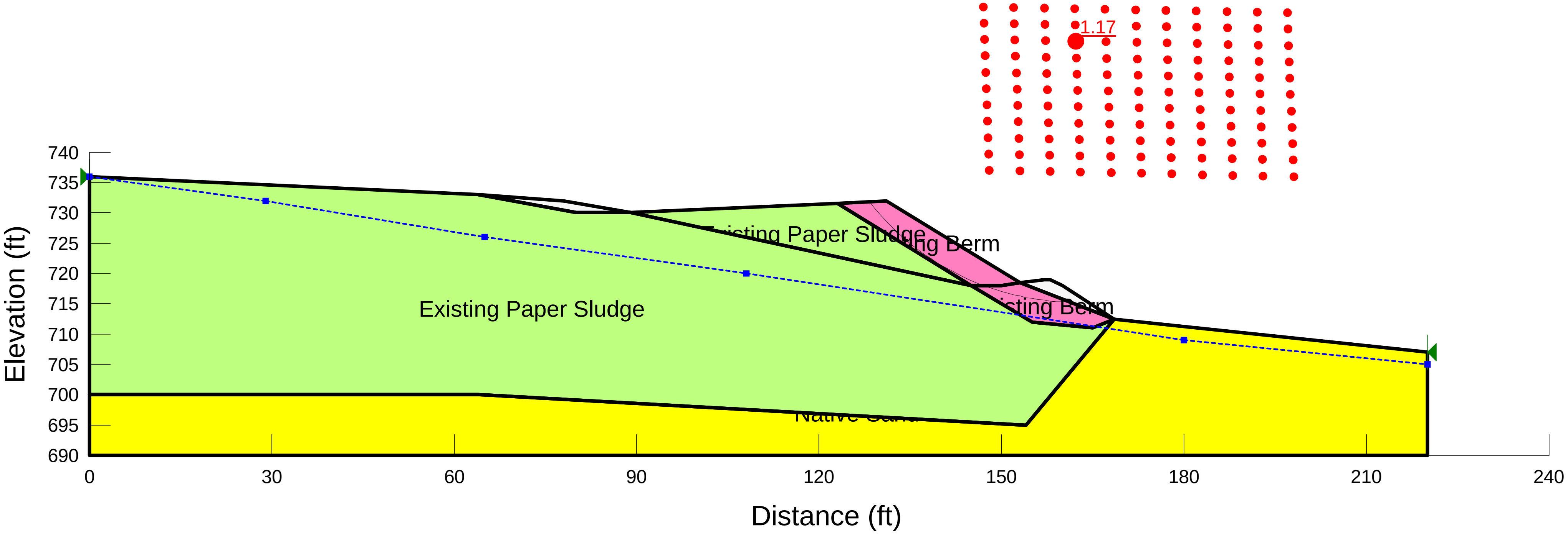


Figure A3
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

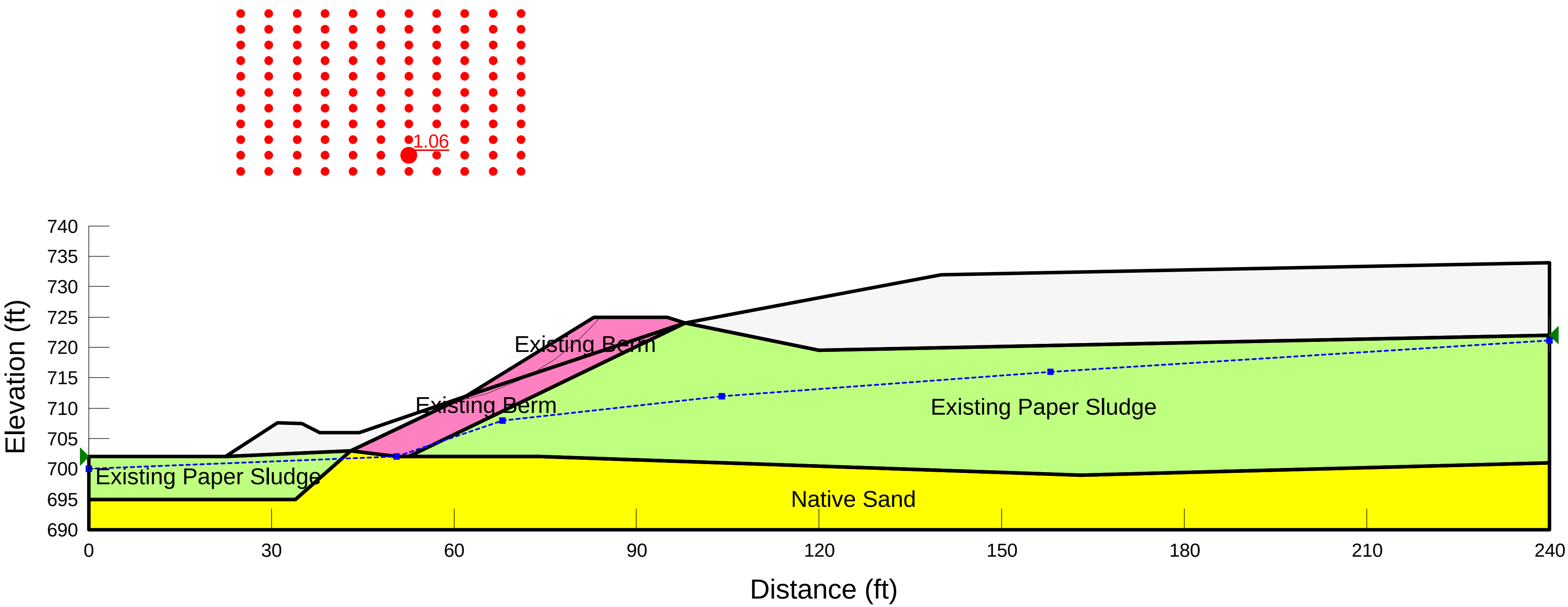


Figure A4
Section C-C
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm   Unit Weight: 110 pcf   Cohesion: 5 psf   Phi: 30 °
Name: Existing Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 28 °
Name: Native Sand   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °

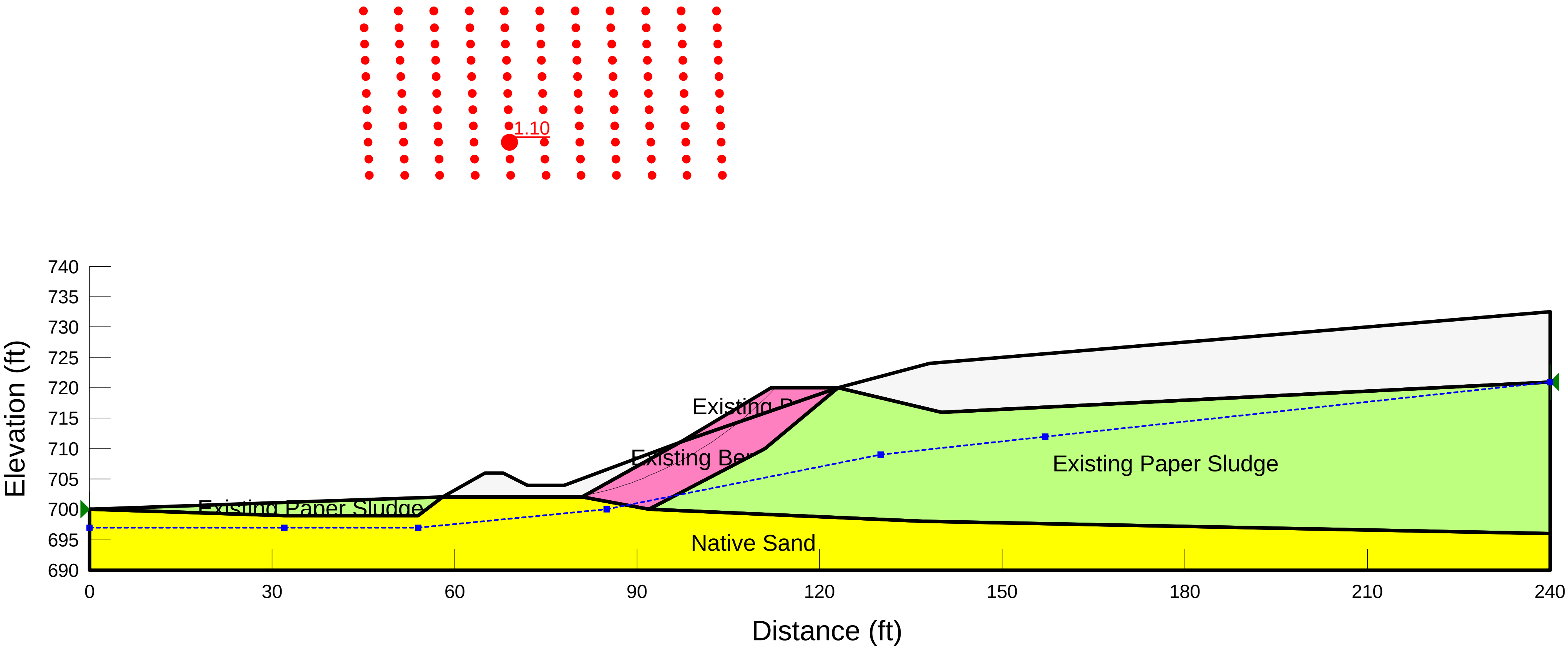


Figure A5
Section C1-C1
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

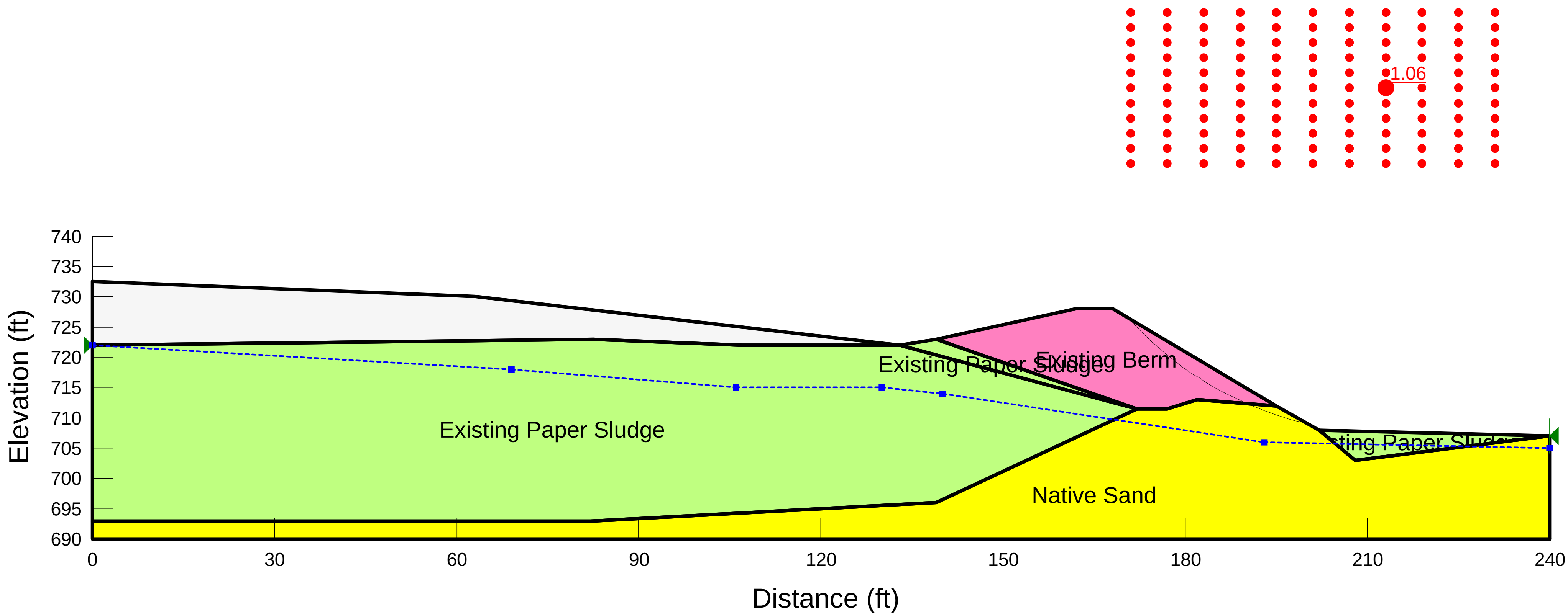


Figure A6
Section D-D
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 120 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

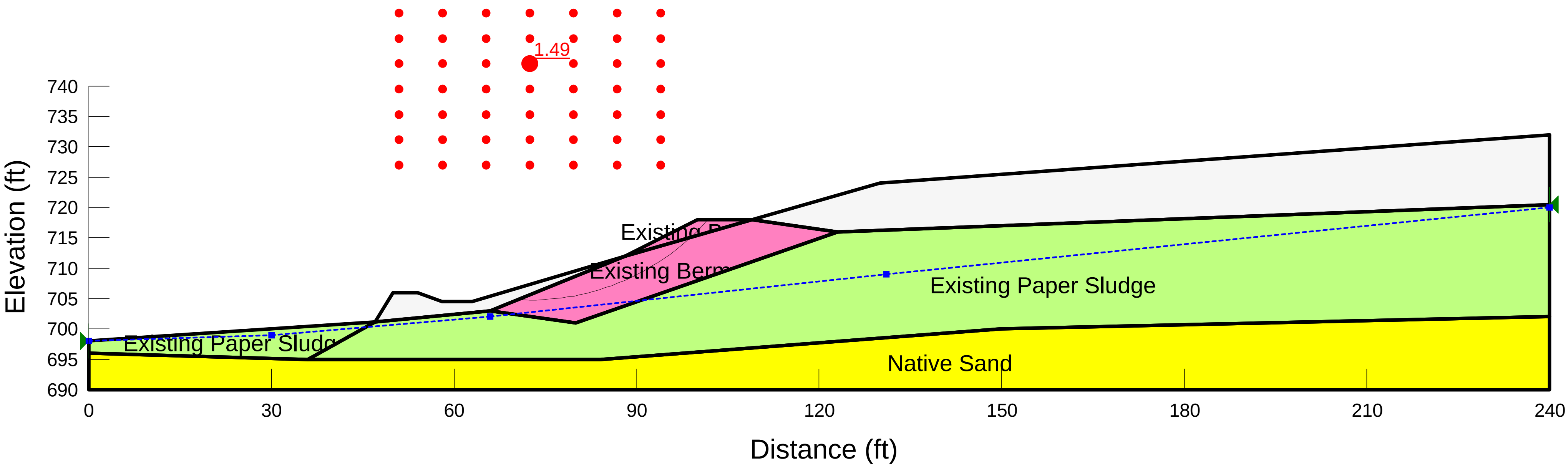


Figure A7
Section E-E
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 35 °

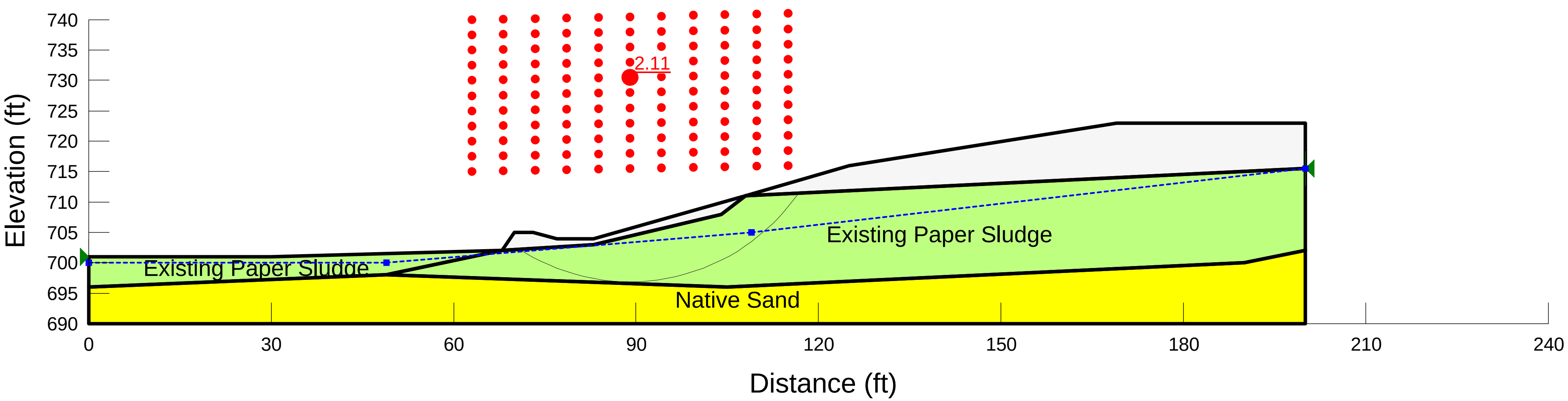


Figure A8
Section E1-E1
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

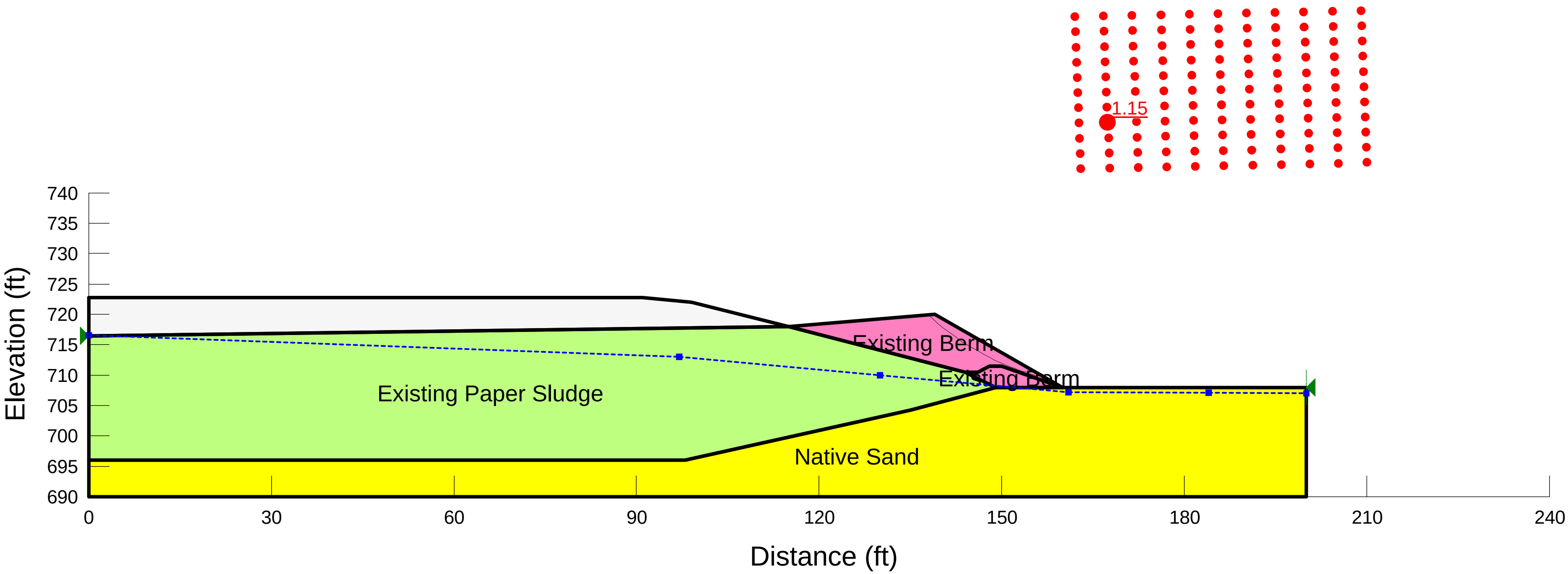
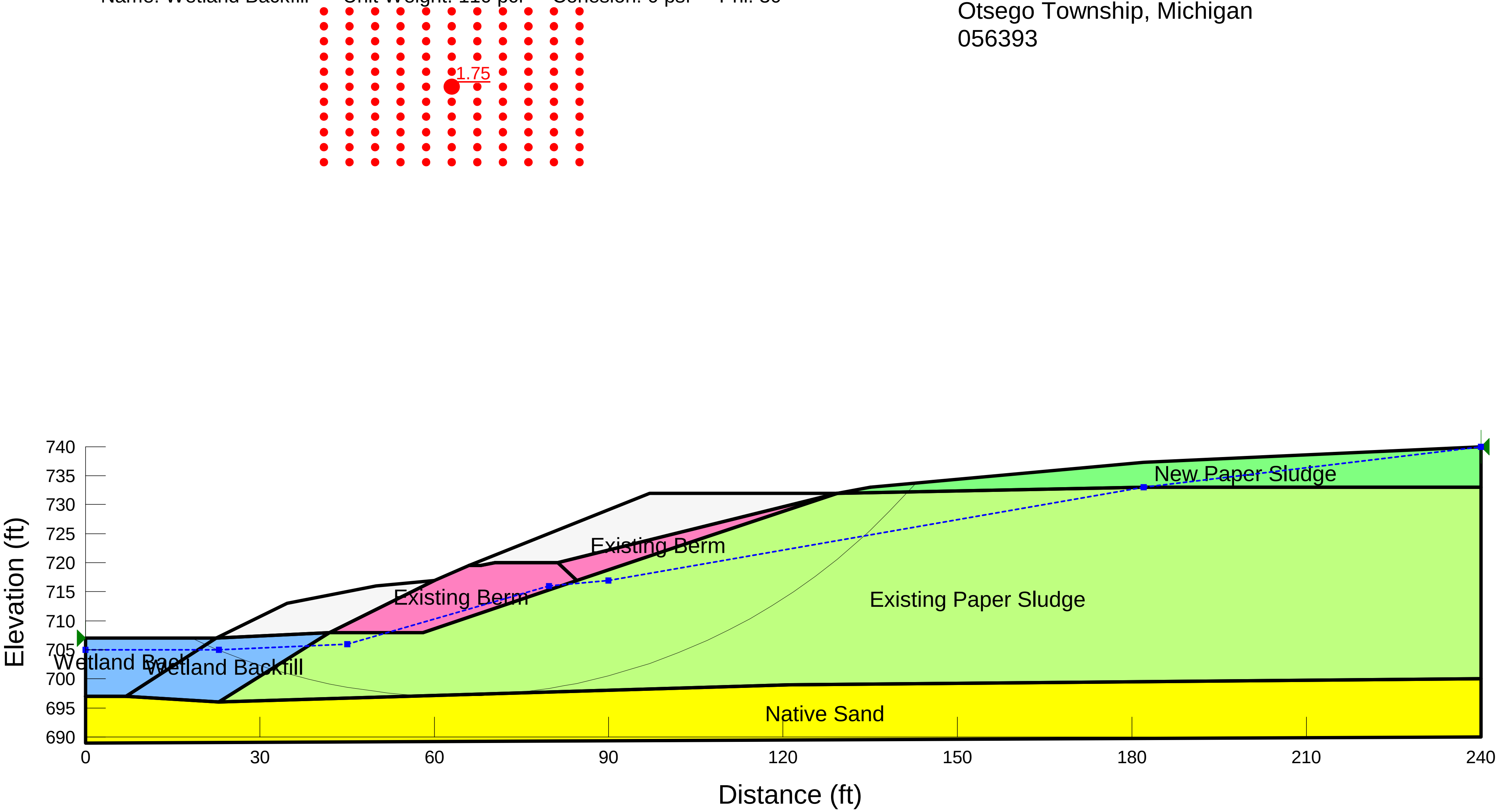


Figure A17
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Wetland Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °



Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

Figure A18
Section A1-A1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

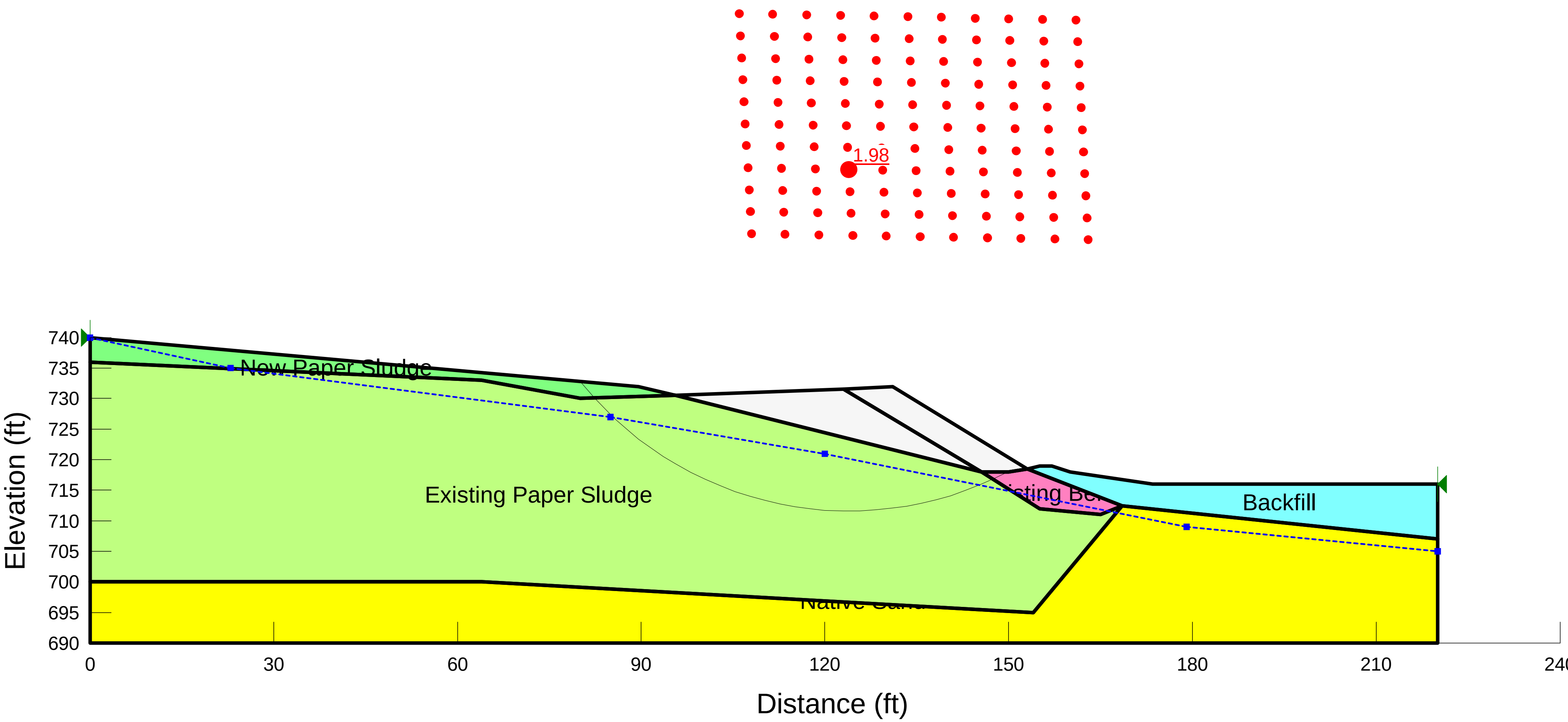
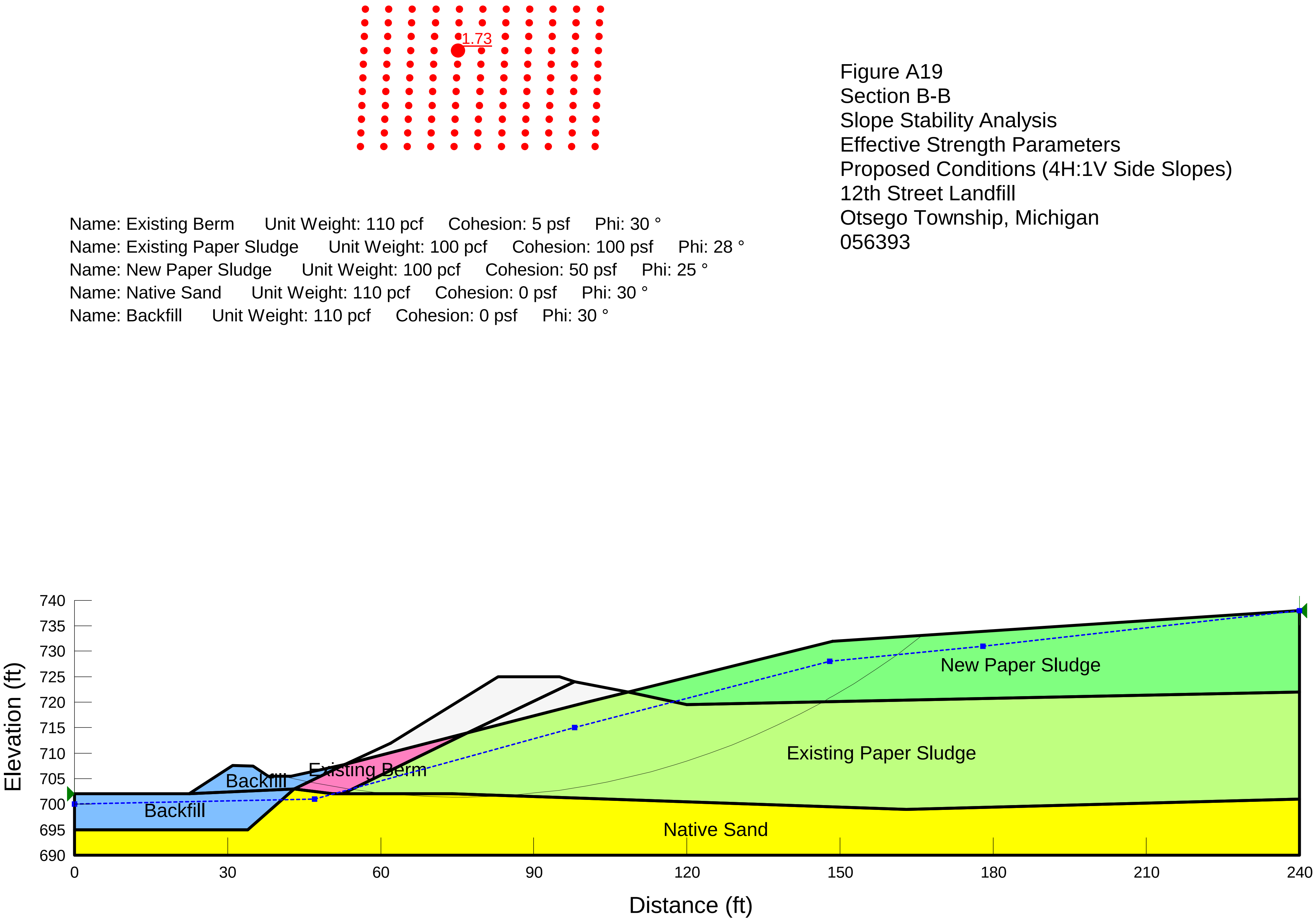


Figure A19
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °



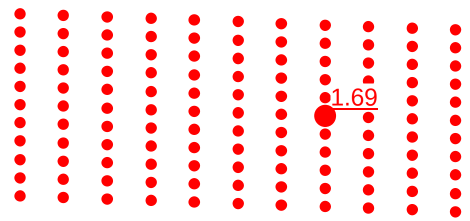


Figure A20
Section C-C
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

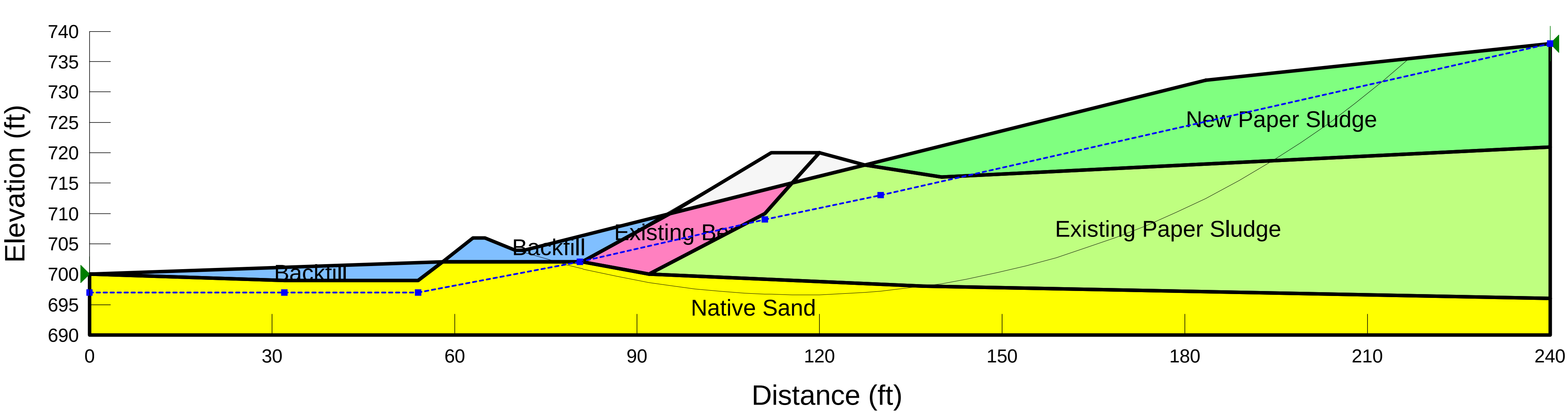
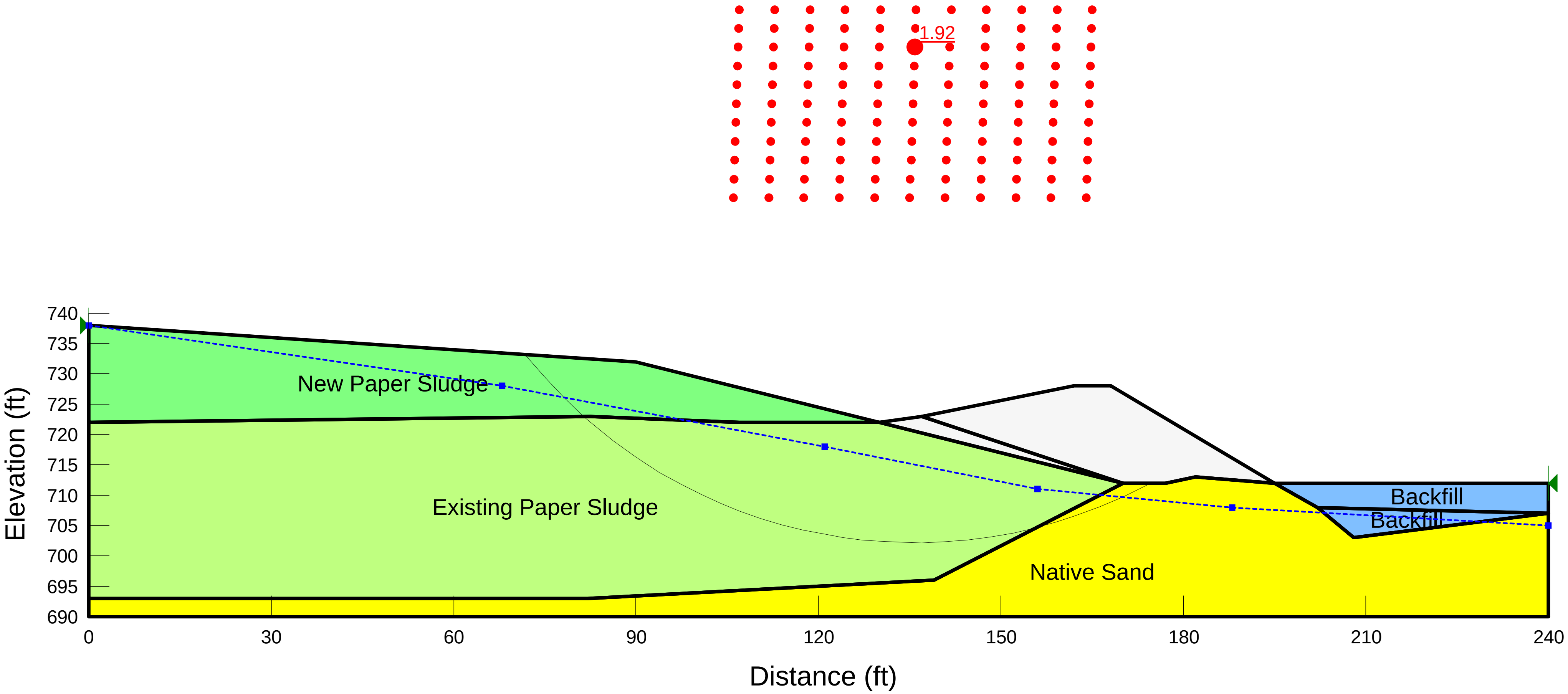


Figure A21
Section C1-C1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °



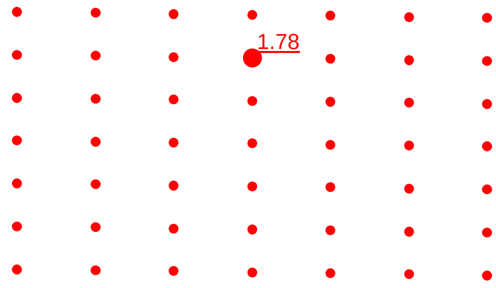


Figure A22
Section D-D
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name	Unit Weight	Cohesion	Phi
Name: Existing Berm	Unit Weight: 120 pcf	Cohesion: 5 psf	Phi: 30 °
Name: Existing Paper Sludge	Unit Weight: 100 pcf	Cohesion: 100 psf	Phi: 28 °
Name: New Paper Sludge	Unit Weight: 100 pcf	Cohesion: 50 psf	Phi: 25 °
Name: Native Sand	Unit Weight: 110 pcf	Cohesion: 0 psf	Phi: 30 °
Name: Backfill	Unit Weight: 110 pcf	Cohesion: 0 psf	Phi: 30 °

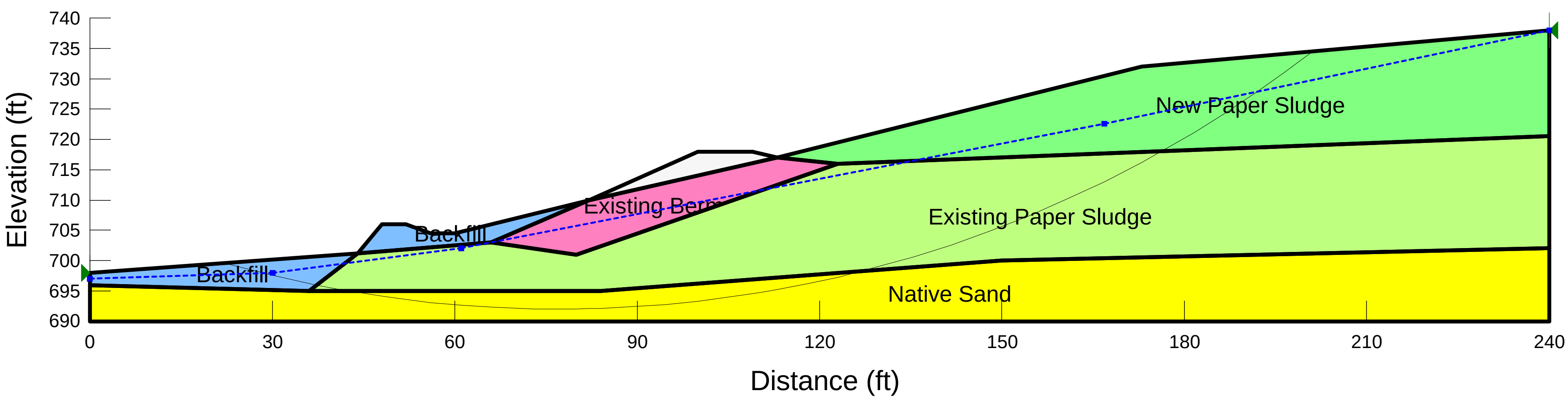
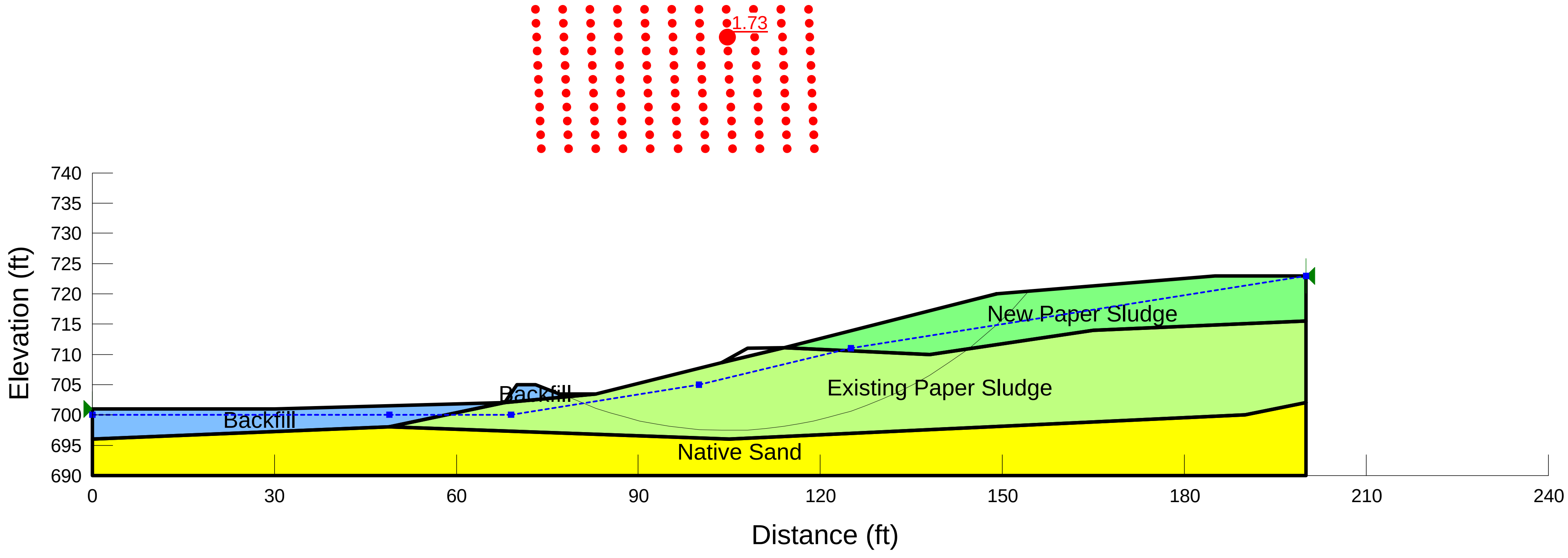


Figure A23
Section E-E
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 35 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °



Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

Figure A24
Section E1-E1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

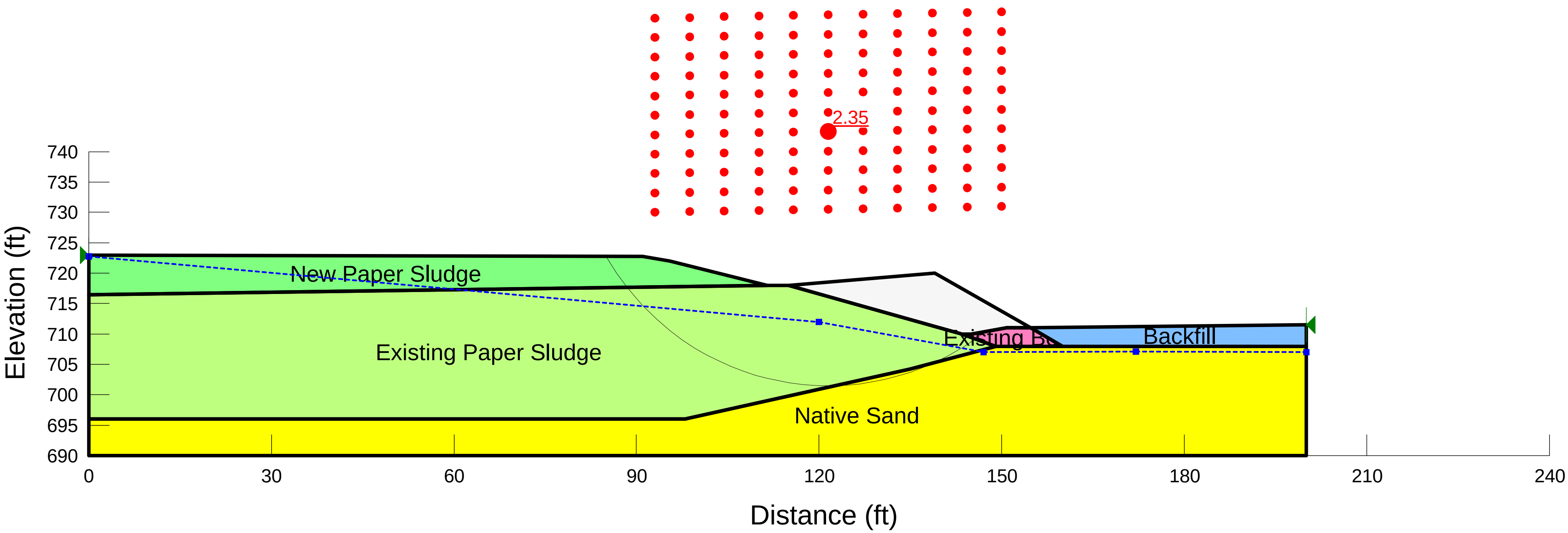


Figure A25
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Construction Conditions
Excavation before building slopes
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

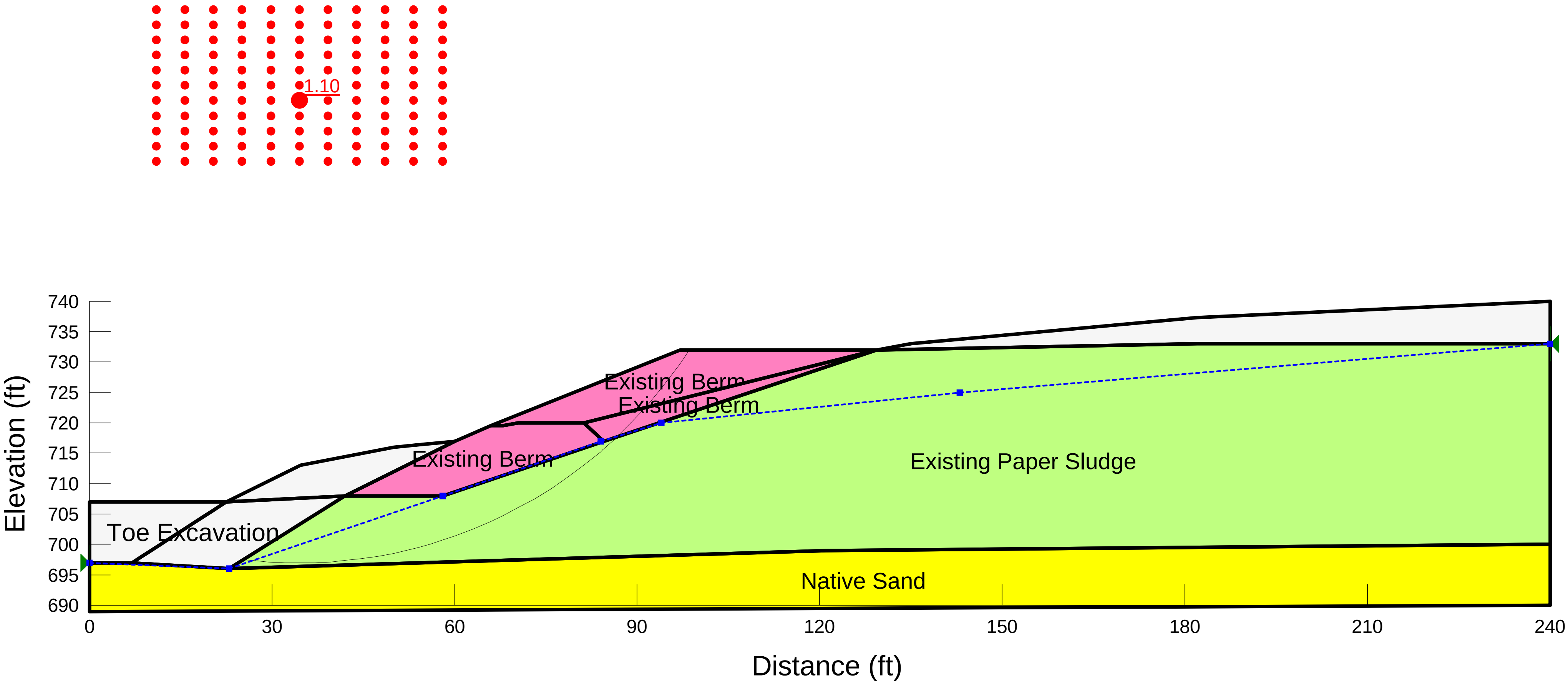


Figure A26
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Construction Conditions
Excavation After Buidling 4:1 Side Slopes
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

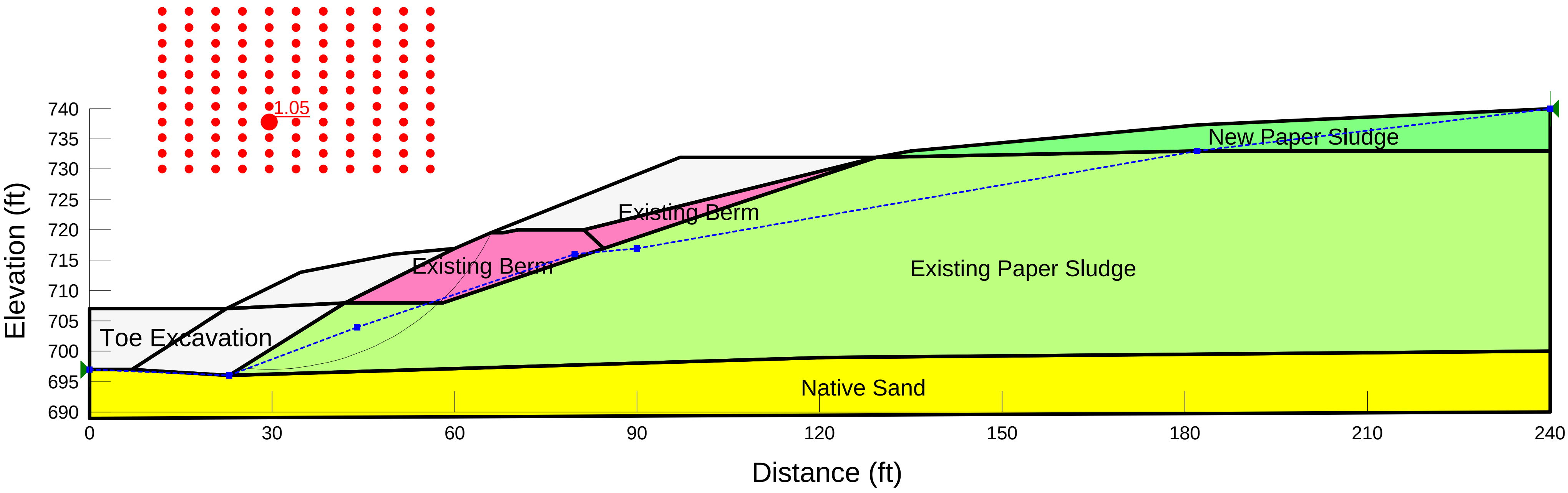
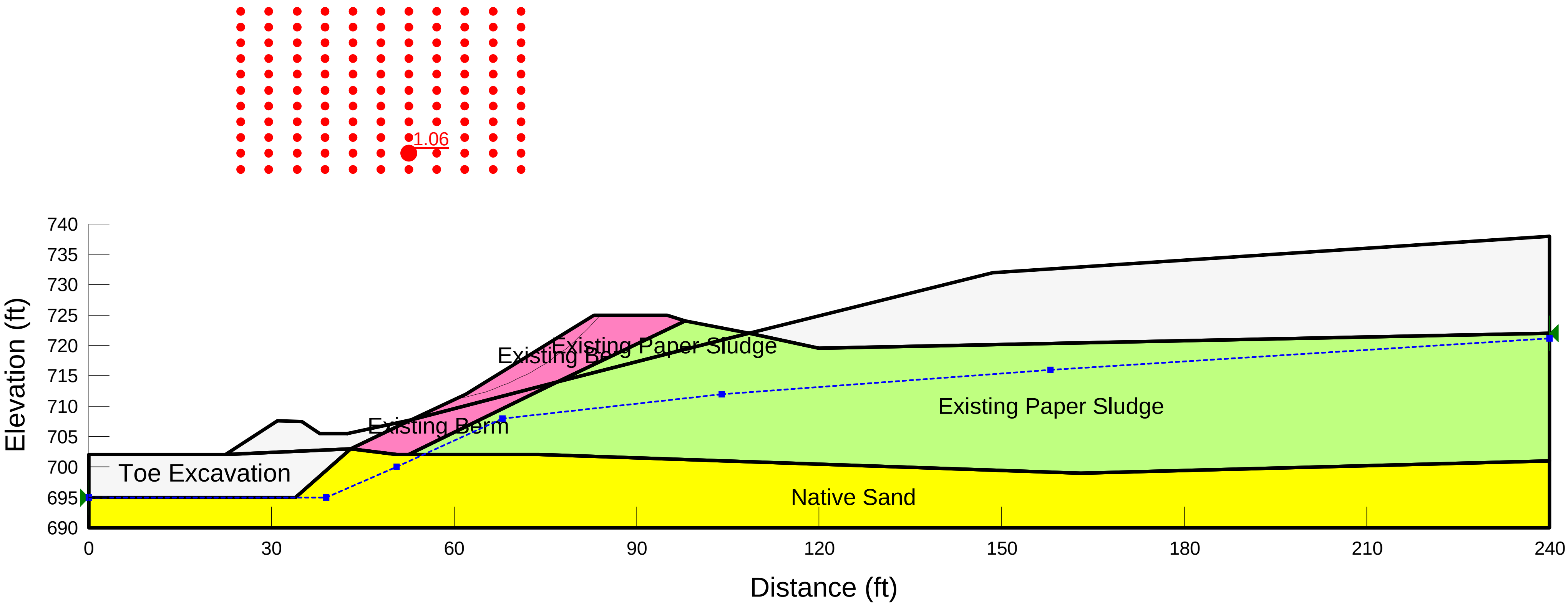


Figure A27
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Construction Conditions
Excavation before buidling slopes
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °



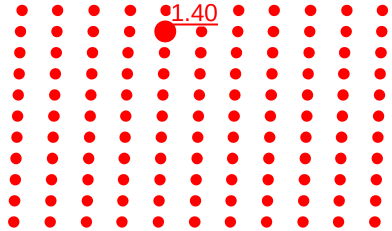


Figure A28
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Construction Conditions
Excavation after building 4H:1V Side Slopes
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm   Unit Weight: 110 pcf   Cohesion: 5 psf   Phi: 30 °
Name: Existing Paper Sludge   Unit Weight: 100 pcf   Cohesion: 100 psf   Phi: 28 °
Name: New Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 25 °
Name: Native Sand   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °

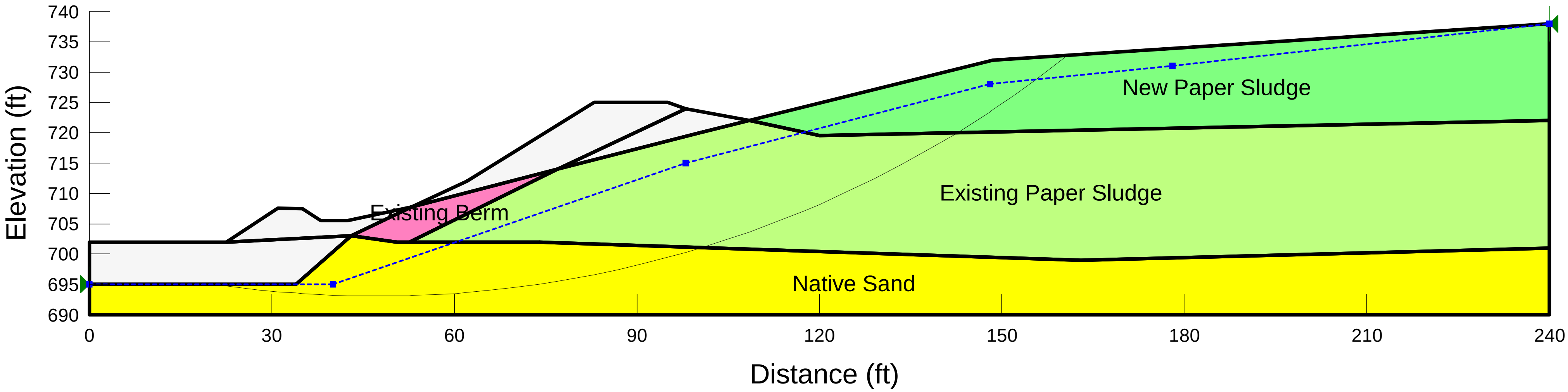


Figure A9
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Wetland Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

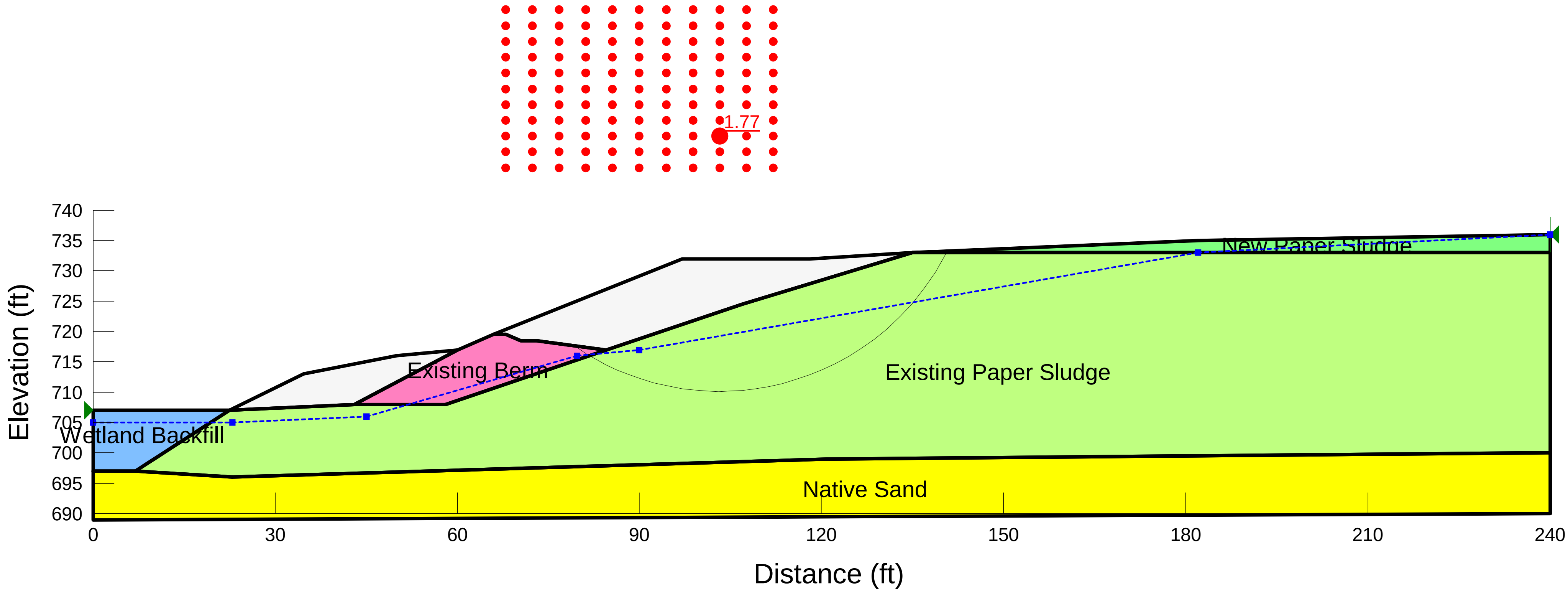
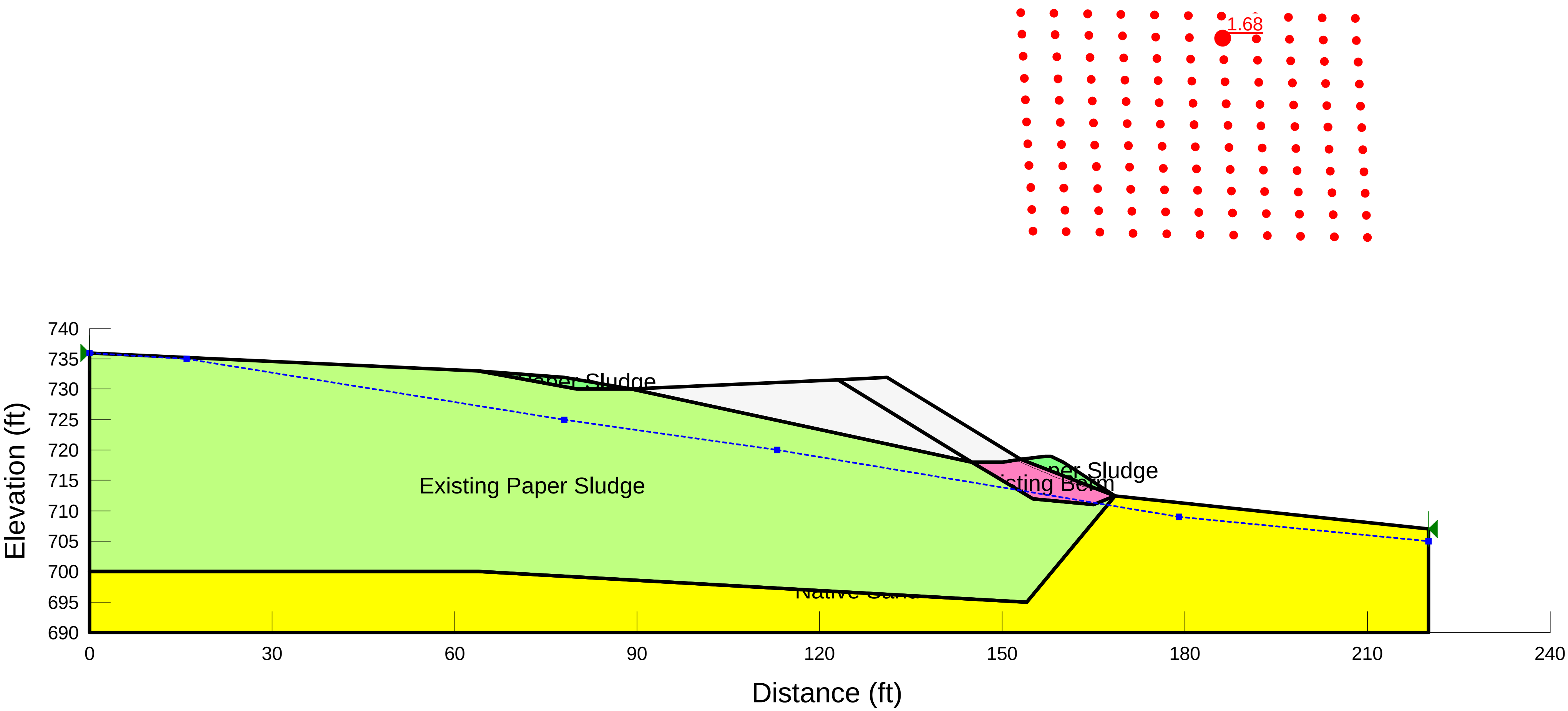


Figure A10
Section A1-A1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °



Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

Figure A11
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

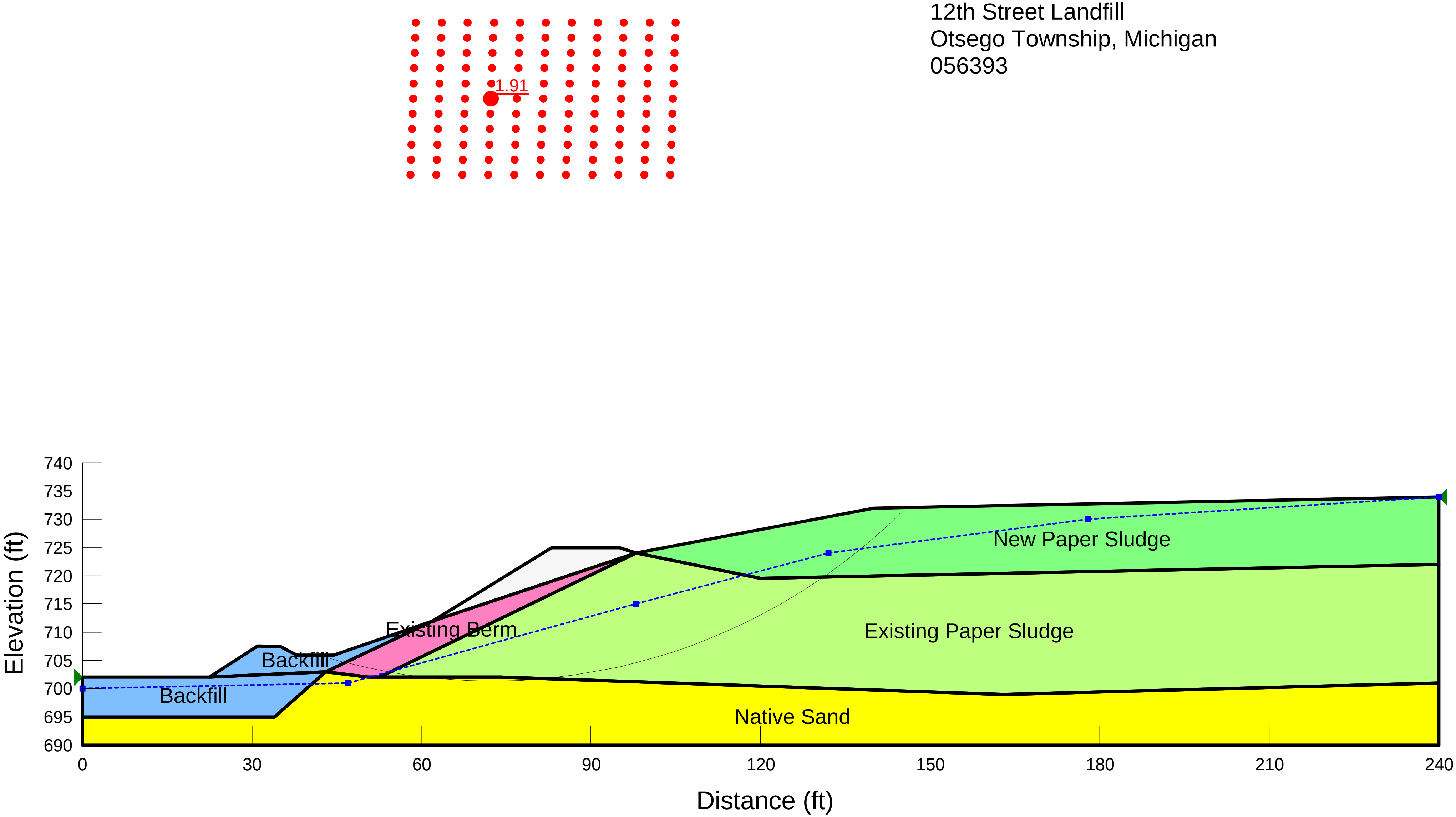


Figure A12
Section C-C
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

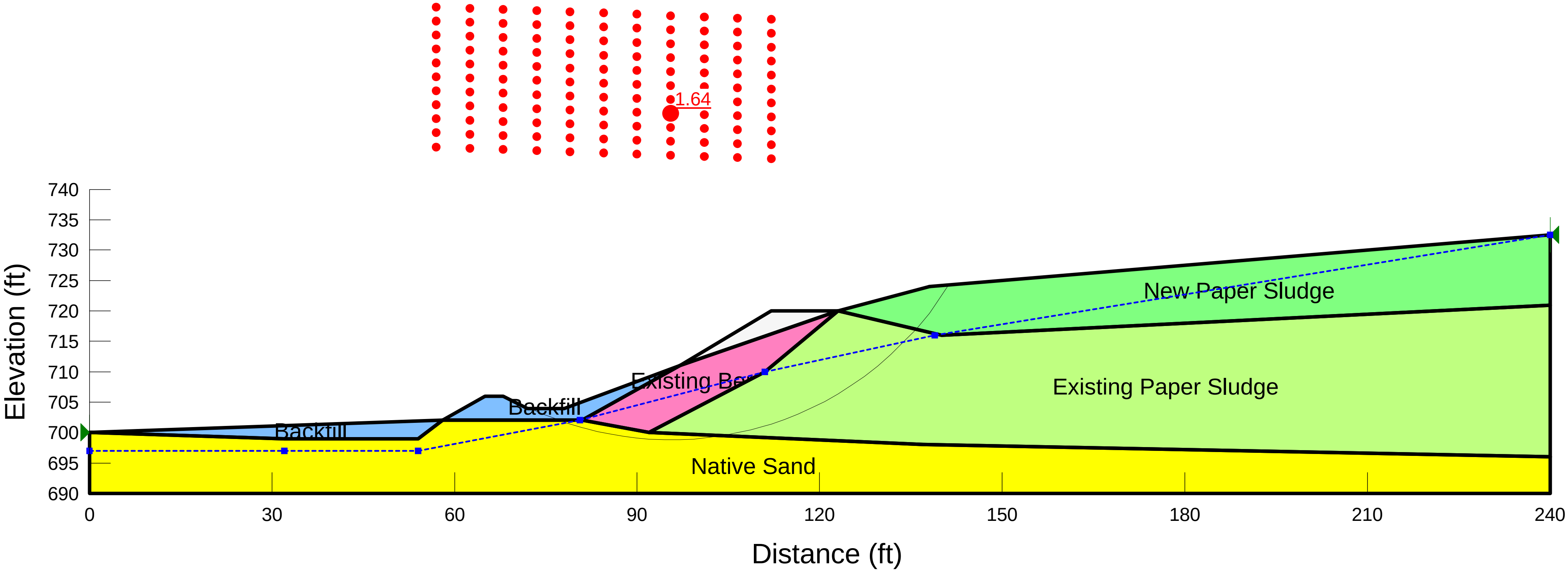


Figure A13
Section C1-C1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

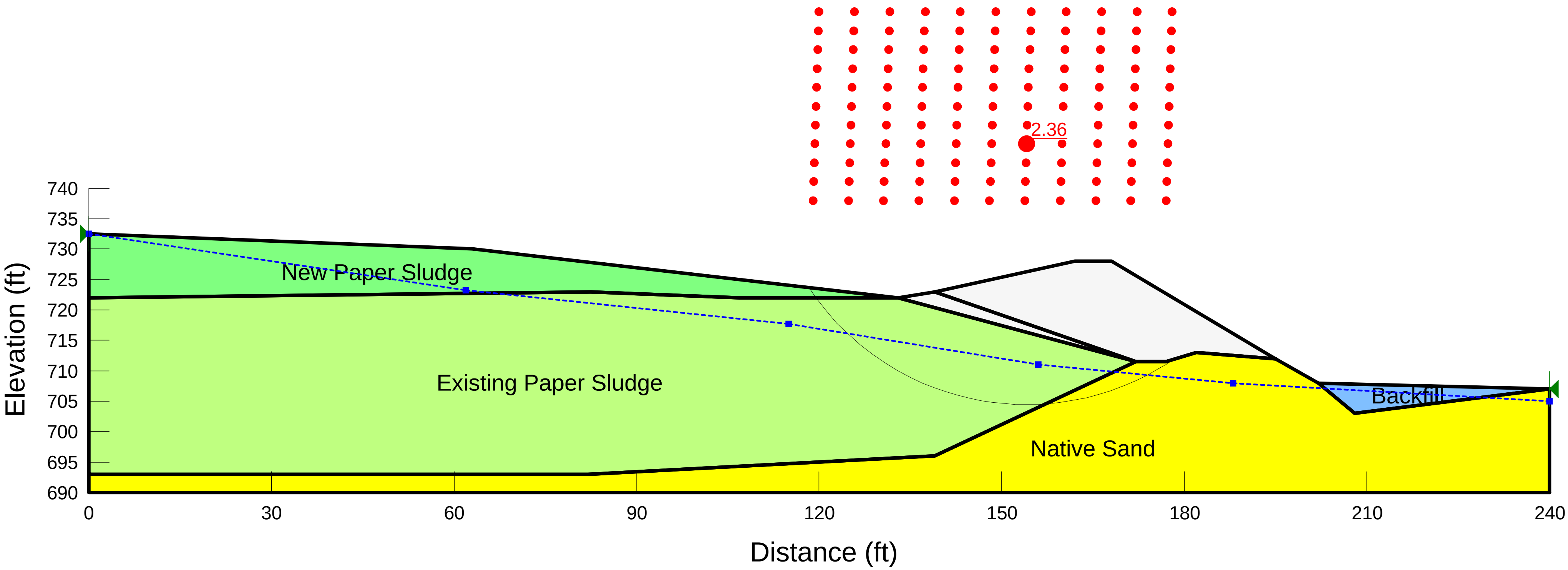


Figure A14
Section D-D
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

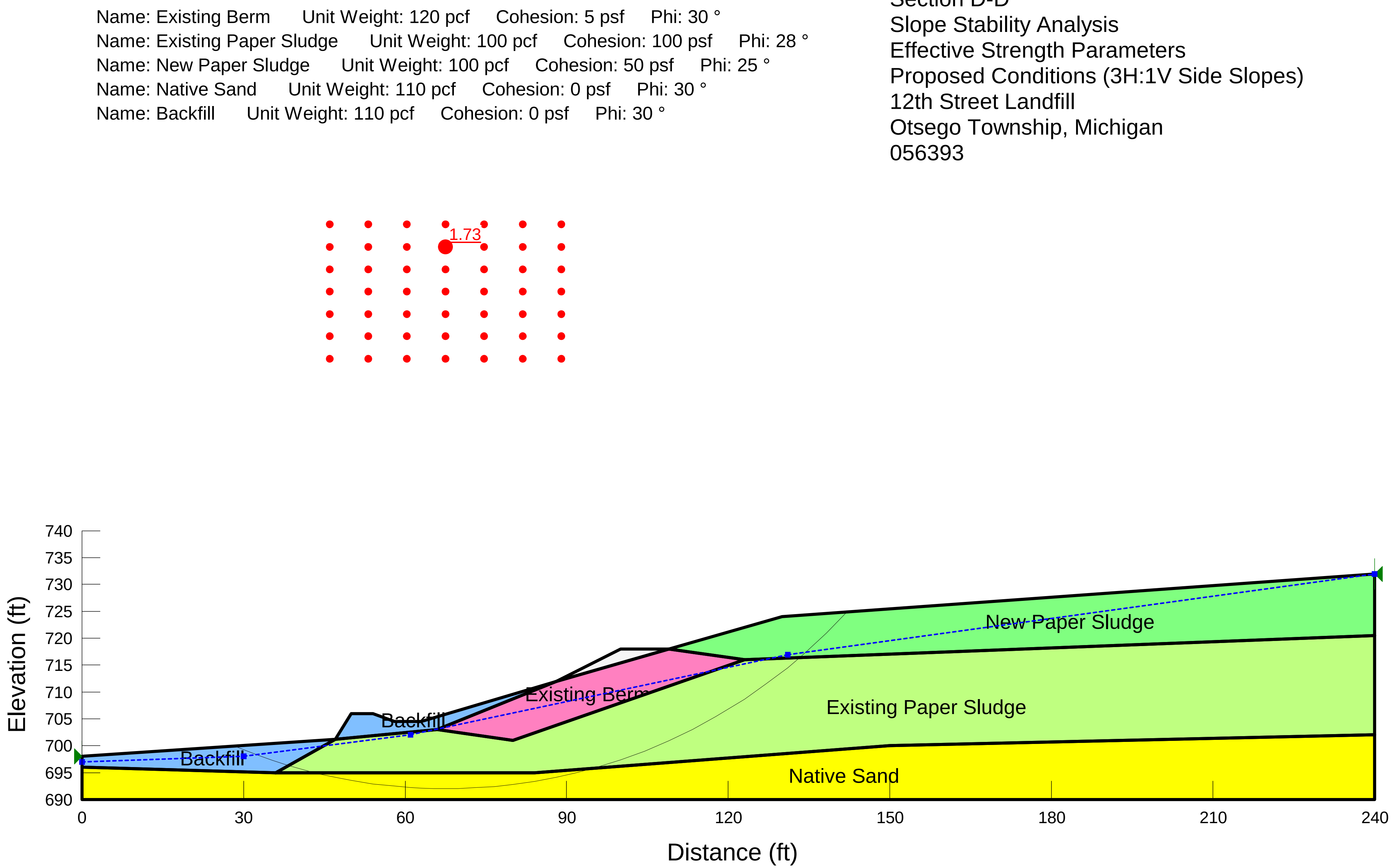


Figure A15
Section E-E
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 35 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

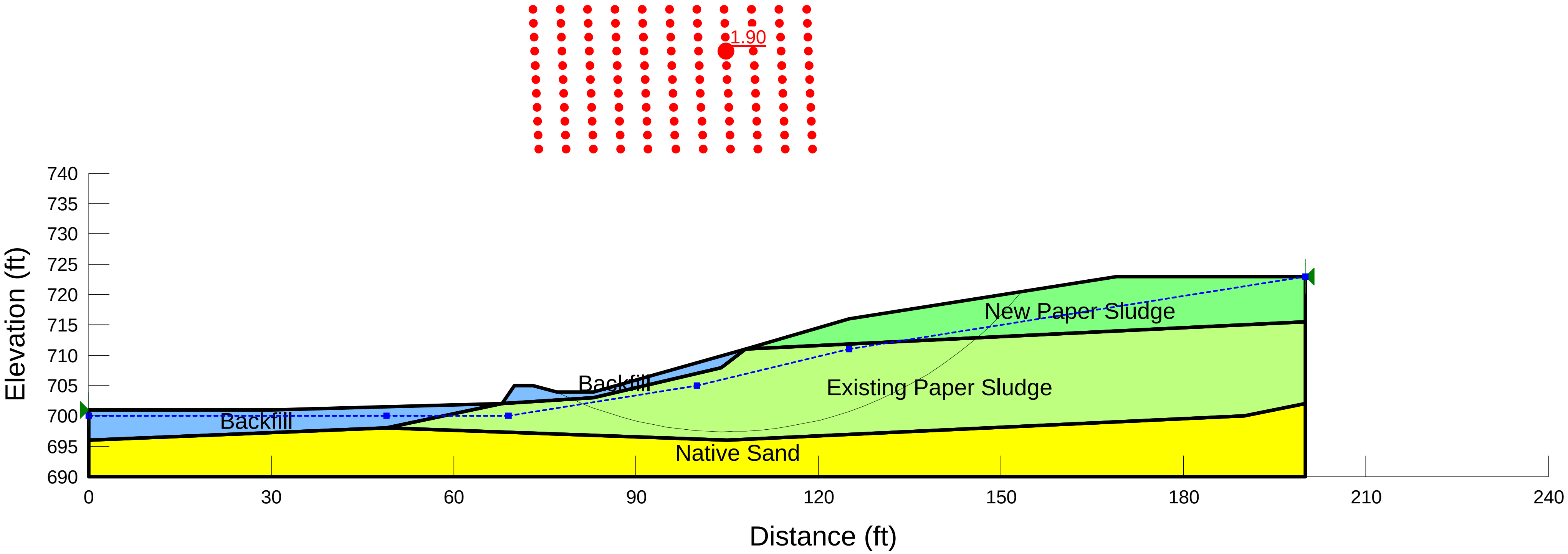
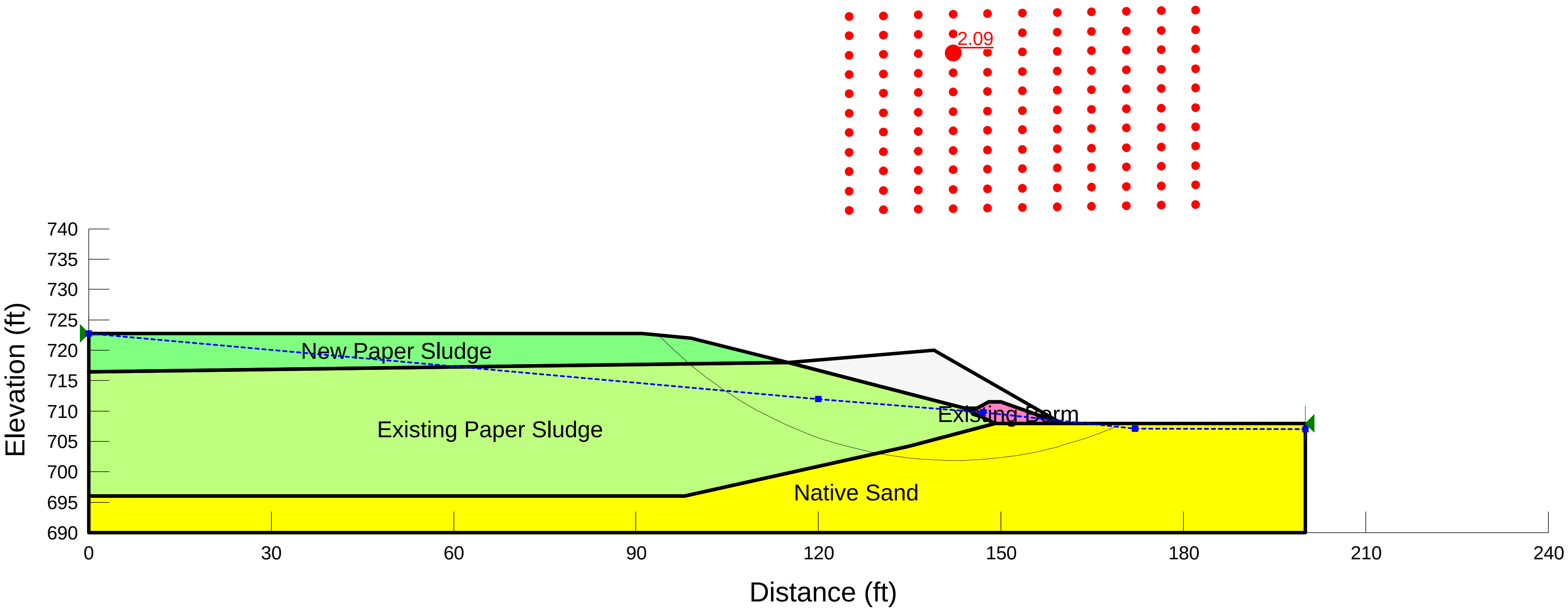


Figure A16
Section E1-E1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °



APPENDIX E

SPECIFICATIONS

- Revised and new specification sections only

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01571	Temporary Erosion and Sediment Control (new)	01571-1 - 01571-5
01720	Field Engineering	01720-1 - 01720-3
	DIVISION 2	
02072	Linear Low-Density Polyethylene (LLDPE) Geomembrane	02072-1 - 02072-20
02073	Drainage Geocomposite (new)	02073-1 - 02073-9
02076	Geotextiles	02076-1 - 02076-5
02215	Gas Probes (new)	02215-1 - 02215-6
02232	Clearing and Grubbing (revised)	02232-1 - 02232-1
02311	Waste Consolidation (new)	02311-1 - 02311-6
02315	Excavation	02315-1 - 02315-2
~~02317~~	~~Trenching, Backfilling, and Compacting~~ (removed)	~~02317-1 - 02317-2~~
02320	Fill	02320-1 - 02320-6
02372	Riprap (revised)	02372-1 - 02372-1
~~02374~~	~~Sediment Control Fence~~ (removed)	~~02374-1 - 02374-1~~
02376	Erosion Control and Revegetation Mat	02376-1 - 02376-2
02377	Geoweb (new)	02377-1 - 02377-5
02506	Landfill Gas Vents (new)	02506-1 - 02506-5
02522	Groundwater Wells	02522-1 - 02522-4
02526	Monitorinq Well Abandonment	02526-1 - 02526 -1
~~02618~~	~~HDPE Piping, Below-Grade~~ (removed)	~~02618-1 - 02618-3~~
02830	Chainlink Fence and Gates	02830-1 - 02630-4
02911	Topsoil (revised)	02911-1 - 02911-1
02921	Seeding (revised)	02921-1 - 02921-3
02923	Fertilizing	02923-1 - 02923-2

SECTION 01571

TEMPORARY EROSION AND SEDIMENT CONTROL

PART 1 GENERAL

1.1 SECTION INCLUDES

A. References.

B. Progress submittals.

C. Quality assurance.

D. Qualifications.

E. Regulatory requirements.

F. Pre-installation meeting.

G. Delivery, storage, and handling.

H. Environmental requirements.

I. Sequencing and scheduling.

J. Products.

K. Examination.

L. Preparation.

M. Installation, monitoring, and maintenance.

N. Field quality control.

O. Cleaning.

1.2 REFERENCES

A. ASTM International (ASTM):

1. D6461 - Standard Specification for Silt Fence Materials.

2. D6462 - Standard Practice for Silt Fence Installation.

B. Guidebook of Best Management Practices for Michigan Watersheds, Michigan Department of Natural Resources, Water Quality Division.

C. Michigan Act 451: Natural Resources and Environmental Protection Act (Part 91) [former Michigan Act 347: Soil Erosion and Sediment Control Act].

1.3 SUBMITTALS

A. Erosion and Sediment Control Plan: Prepare a detailed Erosion and Sediment Control Plan in accordance with Guidebook of Best Management Practices for Michigan Watersheds and Michigan Act 451 Part 91. Submit plan to local authorities for their review. Address each of the following:

1. Marked areas of critical erosion.

2. Marked locations of erosion and sediment control measures.

3. Detailed construction notes and maintenance schedule for temporary and permanent erosion and sediment controls.

1.4 QUALITY ASSURANCE

A. Perform work of this Section in accordance with Michigan Act 451 Part 91 and local erosion and sediment control guidelines.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect silt fence materials from physical damage, or other conditions or substances which may degrade the product.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Do not install erosion and sediment control where there is a possibility of a washout or such that Site waters and sediment are directed onto adjacent properties.

B. Maintain erosion and sediment control during and after installation of landfill cap system.

C. Minimize impacts to on-Site areas not involved in construction activities.

1.7 SEQUENCING AND SCHEDULING

A. Temporary erosion control measures as identified in the approved Erosion and Sediment Control Plan shall be in place and functional prior to initiation of earth work activities.

1.8 PRODUCTS

A. Straw Bale:

1. Wire bound or string tied.

2. Securely anchored by at least 2 stakes or rebars driven through the bale 18 inches into the ground.

3. Chinked (filled by wedging) with straw to prevent concentrated flow of water from escaping between the bales.

4. Entrenched a minimum of 4 inches into the ground.

B. Silt Fence:

1. An assembled, ready to install unit consisting of geotextile attached to driveable posts.

2. Geotextile: Uniform in texture and appearance with no defects, flaws, or tears that would affect its physical properties and contains sufficient ultraviolet ray inhibitor and stabilizers to provide a minimum 2-year service life from outdoor exposure.

3. Net Backing: An industrial polypropylene mesh which is joined to the geotextile at both top and bottom with double stitching of heavy-duty cord. Width of netting: minimum of 3 feet.

4. Posts: Sharpened wood approximately 2 inches square protruding below the bottom of geotextile to allow a minimum of 1 1/2 foot embedment. Post spacing not to exceed 8 feet. Securely fasten each post to the geotextile and net backing by staples suitable for such purpose.

5. ASTM 6461.

1.9 EXAMINATION

A. Verify surface water drainage pattern to ensure proper locating of soil erosion and sediment control features.

B. Verify that surfaces and Site conditions are ready to receive work.

1.10 PREPARATION

A. Preserve natural features, keep cut-fill operations to a minimum, and ensure conformity with topography so as to create the least erosion and to adequately handle the volume and velocity of surface water runoff.

B. Whenever feasible, retain, protect, and supplement natural vegetation.

C. Do not damage, degrade, or in any way cause harm to any existing above-ground structure or appurtenance, below-ground utility, pipe, or structure.

1.11 INSTALLATION

A. Construct temporary erosion control items in accordance with the approved Erosion and Sediment Control Plan.

B. Install silt fence in accordance with ASTM D6462.

C. Whenever sedimentation is caused by stripping vegetation, regrading, or other development, remove it from all adjoining surfaces, drainage systems, and watercourses, and repair damage as quickly as possible.

D. Do not construct straw bale barriers and silt fence sediment barriers in flowing streams or in swales where there is the possibility of a washout.

E. Straw bales and/or silt fence may be removed at the beginning of the work day, but shall be replaced at the end of the work day.

F. Check weekly and after each rainfall erosion and sediment control measures. During prolonged rainfall, daily checking is necessary.

G. Pay close attention to the repair of damaged bales, end runs, and undercutting beneath bales. Where undercutting occurs, augment in place siltation controls with riprap.

H. Prior to or during construction, ENGINEER may require the installation or construction of improvements to prevent or correct temporary conditions on Site. Improvements may include berms, mulching, sediment traps, detention and retention basins, grading, planting, retaining walls, culverts, pipes guardrails, temporary roads, and other measures appropriate to the specific condition. All temporary improvements shall remain in place and in operation until otherwise directed by ENGINEER.

I. Remove all items upon completion of Works. Spread accumulated sediments to form a suitable surface for seeding or dispose of, and shape the area to permit natural drainage; all to the satisfaction of ENGINEER.

1.12 SEDIMENT BARRIERS

A. Straw bale check dams shall be constructed as shown on Drawings.

B. Silt fence sediment barrier shall be installed as shown on Drawings.

C. Straw bale sediment barriers shall be installed as shown on Drawings.

1.13 FIELD QUALITY CONTROL

A. Inspect all temporary erosion control items for proper placement and maintenance.

B. Repairs caused by extreme weather conditions or circumstances not under CONTRACTOR's control will be compensated for as extra work.

1.14 CLEANING

A. Clean straw bales and silt fences of excessive silt accumulation if and when necessary.

B. Remove sediment deposits when the level of deposition reaches approximately one-half the height of the barrier.

END OF SECTION

SECTION 02073

DRAINAGE GEOCOMPOSITE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Drainage geocomposite (geonet) for landfill cap.

1.2 REFERENCES

A. ASTM International (ASTM):

1. D422 - Standard Test Method for Particle Size Analysis of Soils.
2. D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
3. D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
4. D1603 - Standard Test Method for Carbon Black in Olefin Plastics.
5. D4218 - Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique.
6. D4439 - Standard Terminology for Geosynthetics.
7. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
8. D4595 - Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
9. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
10. D4716 - Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
11. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
12. D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
13. D5261 - Standard Test Method for Measuring Mass Per Unit Area of Geotextiles.
14. D7005 - Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites.
15. F904 - Standard Test Methods for Comparison of Bond Strength of Ply Adhesion of Similar Laminates Made From Flexible Materials.

B. Geosynthetic Research Institute (GRI) GC7 – Determination of Adhesion and Bond Strength of Geocomposites.

1.3 DEFINITIONS

A. Geotextile: Synthetic filter fabric for use in geotechnical filter applications.

B. HDPE: High density polyethylene.

C. Drainage Geocomposite: Synthetic HDPE geonet material with prefastened geotextile fabric for use as a drainage layer.

D. Wrinkles: Corrugations which will fold over during placement of overlying material.

E. MD: Machine Direction.

F. CD: Cross Direction.

G. SMDD: Standard Maximum Dry Density and in the context of this Purchase Order means the maximum dry unit weight determined in accordance with ASTM D698.

H. Conform to ASTM D4439 for interpretation of terms used in this Section.

1.4 PROGRESS SUBMITTALS

A. Samples: A representative Sample at least 2 feet by roll width no later than 14 days prior to ordering.

B. Product Data: Submit no later than 14 days prior to ordering. Include installation, handling, storage, and repair instructions.

C. Manufacturer's Certificates:

1. Certificates pertaining to the rolls of material delivered to the Site shall accompany the rolls. Each roll shall be identified by a unique manufacturing number and shall reference the specific rolls of geotextile fabric and gridded HDPE geonet incorporated into the drainage net construction.

2. Include test data for all parameters specified in PART 2.

3. The quality control certificates shall be signed by a responsible party employed by drainage geocomposite manufacturer and shall be notarized.

4. Certificates pertaining to raw materials and manufactured drainage geocomposite rolls shall be provided from drainage geocomposite manufacturer. ENGINEER will review the test results for completeness and for compliance with the required minimum properties for both the raw materials and manufactured drainage geocomposite rolls. Materials and rolls which are in non-compliance with the minimum required properties will be rejected.

D. Daily Field Installation Reports:

1. Provide daily reports of the following:

    1. Total amount and location of drainage geocomposite placed.

    2. Identifiers of rolls and fabricated blankets.

    3. Quality control tests of materials used during the day.

    4. Total amount and location of seams completed.

    5. Seaming procedures used.

    6. Changes in layout drawings.

    7. Location and type of repairs.

    8. Observations of seams around appurtenances and connection to appurtenances.

E. Layout Drawings: Provide drawings of the proposed drainage geocomposite placement pattern and field seams no later than 14 days prior to installation. Indicate panel configuration and location of seams.

F. Manufacturer's Installation Instructions: Submit no later than 14 days prior to installation.

G. Installer Qualifications: Submit a copy of manufacturer's approval letter or license no later than 14 days prior to commencing installation.

H. Manufacturer's Qualifications: Submit, no later than 14 days prior to ordering, a list of previous projects including name of project, description of project, area, client's name and address, contacts, and telephone numbers; engineer's name, address, contact, and telephone number; installer's name, address, contact, and telephone number; and date installed.

I. Transmissivity Testing Reports: Submit no later than 14 days prior to ordering.

1.5 CLOSEOUT SUBMITTALS

A. Record Documents: Indicate panel layout, including panel identifiers, date placed, installer's name, location of seams, and location and details of repairs.

B. Warranties: Completed original warranty forms filled out in OWNER's name and registered with manufacturer.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum 10 projects, 10 million sq ft, manufacturing, and 3 years documented experience.

B. Installer: Trained and qualified to install the type of drainage geocomposite to be used for the project and an approved and/or licensed installer of drainage geocomposite manufacturer with minimum 5 projects, 5 million sq ft installation, and 3 years experience. Submit a copy of the approval letter or license to ENGINEER.

C. Seamers: Personnel performing seaming operations shall be qualified by experience with a minimum of 3 years experience.

1.7 PRE-INSTALLATION MEETING

A. Convene 1 week prior to commencing work of this Section.

B. Purpose of Meeting:

1. Define the responsibilities of each party.

2. Establish lines of authority and lines of communication.

3. Establish Site-specific quality control and monitoring procedures.

4. Define installation procedures.

5. Define the method of acceptance of the completed drainage geocomposite.

6. Define installation schedule.

7. Discuss submittals.

8. Review methods for measuring production.

9. Review methods for protecting installed work.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Package and label drainage geocomposite rolls or blankets prior to shipment to the Site. The label shall indicate drainage geocomposite manufacturer, type of drainage geocomposite, and roll or blanket number.

B. When transported to the Site, handle drainage geocomposite rolls or blankets in accordance with manufacturer's instructions so that no damage is caused.

C. Protect drainage geocomposite from direct sunlight and heat to prevent degradation of drainage geocomposite material and adhesion of individual whorls of a roll or layers of blanket.

D. Take adequate measures to keep drainage geocomposite materials away from possible deteriorating sources.

E. Use handling equipment approved by manufacturer when moving rolled or folded drainage geocomposite from one place to another.

F. Notify ENGINEER 3 days in advance of drainage geocomposite delivery to the Site. Perform joint inspection with ENGINEER upon delivery. Defects or damage will be grounds for rejection of a portion or of an entire roll at the discretion of ENGINEER. Remove roll from the Site and replace with new material. Repair minor damage and other defects as directed by ENGINEER.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Install drainage geocomposite in accordance with manufacturer's installation instructions.

B. Suspend installation operations whenever climatic conditions, as determined by ENGINEER, are unsatisfactory for placing drainage geocomposite to the requirements of this Section.

C. Weather Conditions for Seaming: Comply with manufacturer's installation instructions.

1.10 SEQUENCING AND SCHEDULING

A. Coordinate the installation of drainage geocomposite with liner installation.

1.11 MANUFACTURER'S WARRANTY

A. Provide 5-year manufacturer's warranty against manufacturing defects.

B. Warranty: Include coverage for:

1. Defective products found to be not in compliance with the requirements of this Section.

2. Replacement of the drainage geocomposite with new material including costs associated with drainage geocomposite installation.

C. Fill out original warranty forms in OWNER's name and register with manufacturer.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Tenax Corporation or approved equal.

2.2 DRAINAGE GEOCOMPOSITE

A. Incorporate a prefabricated gridded HDPE geonet made of overlapping polyethylene strands which transmits fluids in the plane of the net.

B. Incorporate a nonwoven geotextile fabric prefastened to the top surface of HDPE geonet and a nonwoven geotextile fabric prefastened to the bottom surface of HDPE geonet.

C. Complying with the specifications listed in Paragraphs 2.2 D, 2.2 E and 2.2 F.

D. Geotextile fabric shall conform to acceptable values listed as follows:

Property	*Unit*	*Test Method*	*Acceptable Value*
Fabric Weight	ounce per sq yd	ASTM D5261	5.6 (minimum)
Grab Strength (MD/CD)	pound	ASTM D4632	170 (minimum)
Grab Elongation (MD/CD)	percent	ASTM D4632	50 (maximum)
Permittivity	sec^{-1}	ASTM D4491	1.5 (minimum)
Puncture Strength	pound	ASTM D4833	90 (minimum)
Apparent Opening Size (AOS)	Sieve Size mm	ASTM D4751	70 (maximum) 0.210 (maximum)

E. Drainage net shall comply with the following specifications:

Property	*Unit*	*Test Method*	*Minimum Acceptable Value*
Density	g/cc	ASTM D1505	0.94
Carbon Black Content	percent	ASTM D1603 or ASTM D4218	2.0
Tensile Strength (MD)	pounds per inch	ASTM D5035	75

F. Drainage geocomposite shall comply with the following specifications:

Property	*Unit*	*Test Method*	*Minimum Acceptable Value*
Ply Adhesion	pounds per inch	GRI GC7 and ASTM F904 Modified or ASTM D7005	1.0

2.3 SOURCE QUALITY CONTROL

A. Drainage geocomposite shall have the following minimum flow rate capacities when tested in accordance with ASTM D4716 at 1,000 pounds per sq ft confining pressure and sandwiched between the materials to be used in the cap. Perform transmissivity testing at gradients of 0.10 and 0.20.

Gradient	*Minimum Transmissivity after 14 Days Confining Pressure*
0.10	7.13×10^{-4} m^2/sec
0.20	9.9×10^{-5} m^2/sec

PART 3 EXECUTION

3.1 EXAMINATION

A. Obtain ENGINEER's approval prior to installing drainage geocomposite and prior to placing subsequent materials on drainage geocomposite.

3.2 PREPARATION

A. Prior to placement of drainage geocomposite, ensure underlying surfaces are smooth. The surface shall provide a firm, unyielding foundation for drainage geocomposite with no sudden, sharp, or abrupt changes or break in grade.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Place individual sheets and/or strips of drainage geocomposite side by side without gaps.

C. Lay drainage geocomposite smooth and free of tension, folds, or wrinkles.

D. Protect properly placed drainage geocomposite from displacement or damage until and during placement of overlaid materials.

E. In the presence of wind, secure drainage geocomposite with sandbags until overlying cover materials are installed.

F. Ensure that the underlying materials are not damaged during placement of drainage geocomposite.

G. Ensure that stones, mud, and soil are not entrapped in the drainage geocomposite during and following placement and/or seaming operations.

H. Anchor drainage geocomposite and roll down the slope in such a manner as to continually keep the material in tension.

I. Overlap geotextile fabric prefastened to the drainage geocomposite to adjoining section of drainage geocomposite in accordance with manufacturer's instructions; bond by thermal methods, or by sewing in accordance with manufacturer's instructions.

J. If sewing is performed, use thread polymeric material with chemical resistance similar to the geotextile.

K. Drainage net may be butt joined or lapped, except for joints perpendicular to slope direction on slopes shall be overlapped at least 2 feet.

L. Apply nylon/plastic cable ties to the net edge at 5-foot intervals along the edge.

M. Make end splices as follows: On slopes, overlap the upslope sheet 2 feet over the downslope sheet and apply 2 rows of cable ties. Space ties at 2 feet and stagger spacing in the 2 rows.

N. Install drainage geocomposite around wells or other structures in accordance with manufacturer's written specifications.

O. Stagger horizontal seams on side slopes between rolls.

3.4 REPAIR PROCEDURES

A. Geotextile:

1. Clean and dry surfaces at the time of repair.

2. Repair holes or tears in geotextiles by patching with the same geotextile.

3. Patches: Minimum of 12 inches larger in all directions than the area to be repaired, and spot bonded thermally.

B. Drainage Geocomposite:

1. Clean and dry surfaces at the time of repair.

2. Repair holes or tears in the drainage net by patching with the same drainage net.

3. Patches: Minimum of 12 inches larger in all directions than the area to be repaired. Tie the patch in place using a minimum of 4 nylon cable ties.

3.5 INSTALLATION OF MATERIALS IN CONTACT WITH DRAINAGE GEOCOMPOSITE

A. Cover drainage geocomposite with a minimum of 12 inches of cover soil.

B. Place soil cover materials in a manner so as not to damage drainage geocomposite, and in accordance with drainage geocomposite manufacturer's instructions.

C. Cover material placement equipment shall push the cover material in front of it, traveling only on the previously placed cover material, never directly on drainage geocomposite. No sudden turns or accelerations which may abrade the covered drainage geocomposite shall occur while equipment is directly above drainage geocomposite.

D. Minimize slippage of drainage geocomposite and assure that no tensile stress is induced in the materials.

3.6 FIELD QUALITY CONTROL

A. Inspect each panel in place for damage, tears, overlaps, and consistency before placing material thereon. Mark damaged panels or portions of damaged panels which have been rejected, as judged by ENGINEER, and record their removal from the work area. Repair or replace damaged or improperly placed sections as judged by ENGINEER.

3.7 MANUFACTURER'S FIELD SERVICES

A. Manufacturer shall provide a qualified representative to observe installation of drainage geocomposite.

B. Manufacturer's representative shall have extensive knowledge of drainage geocomposite liner product, specifically as it pertains to proper construction techniques for waste management applications.

C. Manufacturer's representative shall be on the Site for a minimum of first week of installation and shall remain on the Site until, in its opinion, CONTRACTOR and/or installer can adequately complete the installation in strict accordance with specifications and the installation procedure specified in this Section.

3.8 PROTECTION OF FINISHED WORK

A. Protect finished work from damage.

B. Do not permit traffic or construction equipment directly on drainage geocomposite.

END OF SECTION

SECTION 02215

GAS PROBES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Drilling and installation of landfill gas probes and multi-level perimeter gas probe.

1.2 REFERENCES

A. ASTM International (ASTM):

1. A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

2. D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules40, 80, and 120.

3. D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

1.3 PROGRESS SUBMITTALS

A. Product Data: Include manufacturer's data sheets for pipe materials and screens.

B. Manufacturer's Certificates: Certify that products meet or exceed specified requirements.

1.4 PROGRESS SUBMITTALS

A. Record Documents: Accurately record actual locations of probes, depth, subsoil strata, and drilling difficulties encountered. Submit a signed copy of driller's log book statements.

1.5 QUALITY ASSURANCE

A. Procure permits, certificates, and licenses required by law for the execution of Works. Request and obtain waivers from authorities having jurisdiction and submit to ENGINEER prior to commencement of work at Site. Comply with federal, state, and local Laws and Regulations relating to the performance of Works.

1.6 QUALIFICATIONS

A. Drilling Firm: Company specializing in performing the work of this Section with minimum 5 years documented experience.

1.7 SEQUENCING AND SCHEDULING

A. Sequence and schedule work subject to the following conditions:

1. Coordinate with cap construction and other interrelated activities.

2. Strictly enforce equipment cleaning before moving from one borehole to the next.

PART 2 PRODUCTS

2.1 GAS PROBE RISER AND PERFORATED SCREEN

A. Riser: ASTM D1785 Schedule 40 PVC, 1/2 inch diameter, threaded.

B. Perforated Screen: ASTM D1785 Schedule 40 PVC, 1/2 inch diameter, threaded, with 4 rows of 1/8-inch diameter holes. Offset each hole 90 degrees from the adjacent hole as shown on Drawings. Total 24 holes per foot of riser pipe.

C. Geotextile: As specified in Section 02076.

D. Fittings: Threaded. The use of solvent glues/cements is not permitted.

E. End Cap: Threaded.

F. Stopcock: Threaded, 1/2-inch PVC valve, with permanent handle.

G. Hose Barb: 1/4 inch diameter.

2.2 PEA GRAVEL

A. Washed3/4-inch clear stone.

2.3 BENTONITE GROUT

A. Mixture of Volclay or Benseal; ratio of 2.1 pounds of bentonite with 1 gallon of water to yield minimum density of 9.4 pounds per gallon.

2.4 CEMENT-BENTONITE GROUT

A. Mixture of 10 gallons of water per 94-pound bag of normal Portland cement; add approximately 8 pounds of bentonite powder per bag of cement to slurry. Quantity of bentonite not to exceed 5 percent by weight of mixed slurry, to avoid excessive shrinkage of grout.

2.5 BENTONITE PELLET SEAL

A. Selected by CONTRACTOR for the purpose intended and subject to ENGINEER's approval prior to use.

2.6 PROTECTIVE SURFACE CASING

A. ASTM A53/A53M Schedule 40, 6-inch and 8-inch round (for single and multiple gas probes, respectively) carbon steel with pipe fittings (centering ring) of same standard and a lockable cap welded to a hinge with the hasps welded directly to the side of the protective casing.

2.7 CONCRETE SURFACE SEAL

A. Pre-mixed concrete mixed to manufacturer's specifications with potable water, and developing a minimum compressive strength of 3,000 psi at 28 days.

2.8 WATER

A. Clean potable water obtained from off-Site source approved by ENGINEER.

2.9 OTHER MATERIAL

A. Selected by CONTRACTOR for the purpose intended and subject to ENGINEER's approval prior to use.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that Site conditions support equipment for performing drilling operations.

B. Mark the location of each probe prior to commencement of drilling operations for inspection by ENGINEER.

C. Do not commence drilling operations until ENGINEER has inspected the location of each probe.

D. Obtain ENGINEER's approval for any material introduced into borehole.

3.2 PREPARATION

A. Equipment Cleaning:

1. Upon mobilization to Site and prior to commencing drilling, take drill rig and associated equipment to the designated on-Site Equipment Decontamination Facility and thoroughly clean with a high-pressure, low-volume, hot water wash to remove mud and other foreign matter; ensure drill rig and associated equipment are free of mud and hydraulic fluid, seals

and gaskets are intact, and no fluids are leaking. Remove loose paint or encrustation from downhole equipment prior to use; remove by sandblasting prior to mobilization to Site.

2. Take downhole equipment used in construction of soil borings and installation of probes to Equipment Decontamination Facility and clean as specified herein prior to commencing each borehole to prevent cross-contamination from the previous drilling location.

3. Clean drill rig prior to mobilizing to each gas probe location.

4. Clean gas probe screens and casings prior to installation as specified herein.

5. Equipment cleaning as specified herein is in addition to requirements of Section 01500.

B. Methods of Cleaning:

1. Clean downhole drilling equipment such as augers, cutting bits, drill steel, and associated equipment and tools that contact potentially contaminated soil or groundwater with clean, hot water under high pressure using the following wash sequence:

    1. Wash and wipe dry.

    2. Rinse.

2. Clean screens and tubing thoroughly using the following wash sequence:

    1. Sand off printing inks, if present, on the surface of casing.

    2. Wash equipment thoroughly with a detergent (Alconox) high-pressure wash to remove particulate matter or surface film (if any).

    3. Rinse with deionized water.

3.3 DRILLING AND INSTALLATION

A. Construct each gas probe in accordance with the details shown on Drawings and as directed by ENGINEER.

B. Use drilling equipment and methods approved by ENGINEER. Acceptable methods include Geoprobe™, hollow-stem auger, cable tool, and rotosonic. The use of drilling mud is not allowed. The use of potable water to assist in drilling is acceptable.

C. Collect soil samples continuously from ground surface to bottom of the hole. Log soil cores in accordance with ASTM D2487. Provide qualified geologist to log soil samples. Verify depth of boring.

D. Clean hole of loose material.

E. Maintain screen and tubing free of foreign materials.

F. Lower probe into borehole to the elevation shown on Drawings and keep vertical and in place.

G. Place gas probes in center of hole.

H. Equally space multilevel gas probes in the hole.

I. Place pea gravel in a manner that does not damage or disturb the pipe as augers or drill casing is withdrawn.

J. Place bentonite pellet seal as augers or drill casing is withdrawn.

K. Maintain landfill cap system during and after installation of gas probes.

L. Place protective surface casing and concrete surface seal as shown on Drawings.

M. Abandon any gas probe which is not successfully completed due to auger refusal, loss of equipment, or any other reason, as specified in Article 3.5.

N. Prepare log of each borehole/probe installation including stratigraphy and probe completion details.

3.4 GAS PROBE ABANDONMENT

A. In the event of probe abandonment because of loss of tools or equipment, or due to CONTRACTOR negligence, if requested and as directed by ENGINEER, fill the abandoned hole with cement-bentonite grout; if directed by ENGINEER, salvage and remove such items as can be salvaged. Abandonment of an incompleted probe based on the above, including filling, drilling, surface restoration, or other work performed on the abandoned probe will be at no additional cost to OWNER.

END OF SECTION

SECTION 02232

CLEARING AND GRUBBING

PART 1. GENERAL

1.1 SECTION INCLUDES

A. Clearing, stripping, grubbing, removing, and disposing of the trees, shrubs, brush, logs, stumps, roots, windfalls, and other plant life, including dead and decayed matter and fencing, that exists within the construction areas and which are not specifically designated to remain.

1.2 ENVIRONMENTAL REQUIREMENTS

A. Control the amount of dust resulting from operations to avoid creation of a nuisance in the surrounding area.

PART 2. PRODUCTS

NOT USED.

PART 3. EXECUTION

3.1 CLEARING AND GRUBBING

A. Remove trees, shrubs, brush, logs, stumps, natural growth, and fencing within Construction Limits.

B. Remove stumps, roots, and togs to a minimum depth of 2 feet below ground surface.

C. Remove and dispose of structures that obtrude, encroach upon, or otherwise obstruct work.

D. Remove trees and shrubs within marked areas required to adequately conduct work. Remove stumps, main root ball, and surface rock. Leave stumps in place unless removal required for access to Works.

E. When directed by ENGINEER, remove trees and stumps that are designated as trees from areas outside those areas designated for clearing and grubbing; fell such trees, remove their stumps and roots, and dispose of the trees.

F. Clear undergrowth and deadwood, without disturbing subsoil.

G. Remove logs and other organic or non organic debris not suitable for reuse, to a depth of not less than 18 inches below the original surface level of the ground in areas shown on the Drawings to be grubbed and in areas shown on the Drawings as construction areas under this Contract.

H. Fill depressions made by grubbing with common fill and compact in accordance with Section 02320 to make the surface conform with the original adjacent surface of the ground.

I. Remove debris, rock, and extracted plant life.

J. Chip trees, logs, stumps, roots, brush, rotten woods, and other vegetation obtained from the clearing and grubbing operations that are less than 1 foot in diameter, and stockpile wood chips to be used in erosion control or to be sent off-site.

3.2 DISPOSAL

A. Bury root wads in on-site locations designated by ENGINEER. Remove all other debris and spoil and dispose of off-site. Burning of debris is not permitted.

3.3 PROTECTION OF EXISTING TREES AND VEGETATION

A. Preserve and protect from damage trees and vegetation outside the Construction Limits by the erection of barriers or by such other means as circumstances require.

B. Paint any cut or scarred trees and shrubs with asphaltum base tree paint.

END OF SECTION

SECTION 02311

WASTE CONSOLIDATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Excavating waste material from designated areas.

B. Loading and hauling excavated waste material to waste material placement area.

C. Placing and compacting waste material.

1.2 REFERENCES

A. ASTM International (ASTM):

1. D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.3 DEFINITIONS

A. Subsoil: The materials lying below the surface soil, generally devoid of humus or organic matter.

B. SMDD: Standard Maximum Dry Density and in the context of this Contract means the maximum dry unit weight determined in accordance with ASTM D698.

1.4 ENVIRONMENTAL REQUIREMENTS

A. Suspend operations whenever climatic conditions, as determined by ENGINEER, are unsatisfactory for placing fill to the requirements of this Section.

B. After occurrence of heavy rains, do not operate equipment on previously placed material or on approved surfaces until the material has dried sufficiently to prevent occurrence of excessive rutting.

C. Do not place fill in a frozen state or against frozen surfaces or frozen previously placed material. Do not place fill on snow, ice, water, or other objectionable material or on improperly prepared surfaces or previously placed material.

D. Where surfaces or previously placed material have been softened or eroded, remove soft and yielding material or otherwise objectionable or damaged areas and replace with compacted fill as specified by ENGINEER.

E. Where stripped surfaces or previously placed materials have been eroded, let area dry and fill and compact as specified.

F. During excavation or transportation of excavated materials, implement emissions control measures as directed by ENGINEER.

G. Where monitored air particulate levels exceed specified limits during excavation and transportation of excavated materials, implement additional emission control measures to reduce emissions below specified limits.

H. Decontaminate equipment involved in grading activities which may have come in contact with potentially contaminated material before being removed from Site or being relocated to clean areas of Site.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate and sequence cut and fill operations to minimize the need for temporary stockpiling graded materials until required for backfilling. Make every effort to balance cut and fill operations and to ensure that graded material designated for backfill is immediately placed as backfill in Works.

B. Do not allow or cause any of the work performed or installed to be covered up or enclosed prior to required inspections, tests, or approvals.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that survey bench marks and intended elevations for Works are as shown on Drawings.

B. Obtain ENGINEER's approval of graded surfaces or previously placed material prior to placing materials on them.

C. ENGINEER will define the boundaries of grading and waste excavation areas as shown on Drawings, and as determined in the field by ENGINEER, based on visual observations.

3.2 PREPARATION

A. Stake and flag locations of utilities.

B. Identify required lines, levels, contours, and datum locations.

C. Locate, identify, and protect utilities that remain from damage.

D. Notify utility company to remove and relocate utilities.

E. Protect plant life, lawns, and other features remaining as a portion of final landscaping.

F. Protect bench marks, survey control points, and existing structures from grading equipment and vehicular traffic.

G. Maintain and protect from damage wells, utilities, and structures encountered. In the event of disturbance of or damage to any well, utility, or structure, immediately notify ENGINEER. Repair or replace, any well, utility, or structure damaged by CONTRACTOR operations unless specified for demolition or removal.

H. Protect existing surface features which may be affected while work is in progress.

I. Protect existing structures where temporary unbalanced earth pressures are liable to develop on walls or other structures utilizing bracing, shoring, or other approved methods to counteract unbalance.

J. Protect monitoring wells and other structures and pipelines from uplift and displacement or disturbance during grading operations.

K. Employ procedures for grading such that disturbance of wells, utilities, structures, and their foundations is avoided.

L. Protect graded areas from contamination.

M. Obtain direction from ENGINEER before moving or otherwise disturbing wells, utilities, or structures.

N. Remove surface features or obstructions from surfaces to be excavated, within the limits shown on Drawings or as required to construct the finished work. Dispose of such obstructions as directed by ENGINEER.

O. Unless otherwise specified, advise ENGINEER minimum of 48 hours in advance of grading operations to enable ENGINEER to take pre-grading cross-sections.

P. When placing and compacting fill, do not disturb satisfactorily placed material.

Q. Keep surfaces crowned or sloped to grades shown on Drawings so that surfaces will drain freely.

R. Immediately prior to temporary suspension of operations, leave surfaces under construction to specified grades so as to leave surface free of ruts, depressions, or areas that will pond or collect water.

S. Install erosion and sediment controls.

T. Construct facilities required to prevent run-on of surface water flow from areas outside waste material placement area, and to prevent erosion of placed materials from leaving placement area.

3.3 EXCAVATING WASTE MATERIAL

A. Excavate waste material to depths and dimensions shown on the Drawings and as directed by ENGINEER.

B. Keep limits of excavation undisturbed and free of loose, soft, or organic matter.

C. Maintain excavation depth tolerances (typically 6 inches below limit of visible waste material in areas beyond limit of cap) and a minimum of 6 inches beyond limit of waste. Unless directed by ENGINEER, excavation in excess of specified limits shall be considered over-excavation.

D. Should unauthorized excavation be carried below lines and grades shown on the Drawings and in excess of specified limits and tolerance because of CONTRACTOR's operations including errors, methods of construction, or to suit his convenience, correct unauthorized excavation at CONTRACTOR's expense by extending indicated bottom elevation of base of material specified to be placed to unauthorized excavation bottom without altering required top elevation and compact as specified unless otherwise directed by ENGINEER.

E. Whenever possible, load contaminated waste directly into haulage units and transport to on-Site placement area. If necessary, material may be temporarily stockpiled prior to loading. Develop stockpile areas to prevent contact between clean and contaminated materials. Perform loading to minimize contamination of exterior of haulage units and loading area. If the haulage units are to travel clean access roads or clean areas while carrying wet waste material, line the interior of the box of the haulage unit with 6-mil polyethylene sheeting.

F. Perform excavation and trenching in such a manner that only excavation bucket and boom contacts contaminated materials to the extent practical.

G. Where directed by ENGINEER, stage wet waste materials in a temporary stockpile or in other approved manner and allow to drain prior to relocation.

H. Schedule excavation activities in such a manner that access is available to excavation area for additional excavation if directed by ENGINEER.

I. Decontaminate equipment when visibly contaminated or when moving from a significantly contaminated area to one of lesser contamination for excavation work. ENGINEER will direct additional decontamination when required in opinion of ENGINEER.

J. Vehicles hauling waste materials shall not use temporary access roads constructed for cap subgrade construction activities and shall not traverse areas on which clean fill placement has occurred unless previously decontaminated.

K. Backfill excavated waste areas to proposed final grade in accordance with Section 02316.

3.4 WASTE PLACEMENT

A. Place excavated waste in locations shown on the Drawings.

B. Do not dispose of liquid wastes in waste placement areas.

C. Immediately prior to filling areas covered with standing water, evaluate water to determine proper disposal. Pump out water to maintain area in a dry condition during fill placement.

D. Grade placed waste materials to direct precipitation runoff to adjacent completed areas and ultimately to infiltrate into adjacent ground. Do not permit runoff from waste material to migrate off Site.

E. Implement dust control measures as required by means of application of water and limiting maximum speed of vehicles on temporary access roads.

F. Allow precipitation falling within waste placement area to infiltrate into ground. If excessive water accumulates within the waste placement area, halt placement of waste materials until either water infiltrates, or remove water and handle with other generated wastewaters.

G. Place waste material in continuous 12-inch compacted thickness layers and compact to 90 percent of SMDD.

H. Maintain optimum moisture content plus or minus 2 percent of fill materials to attain required compaction density.

I. Slope grade away from structures minimum 2 inches in 10 feet (1.5:100), unless noted otherwise.

J. Make grade changes gradual. Blend slope into level areas.

3.5 PROOFROLLING

A. Perform proofrolling of subgrade surface.

B. Perform proofrolling using a 10-ton, smooth drum vibratory compactor or similar equipment.

C. Each pass of roller shall overlap previous pass by a minimum 25 percent.

D. Cut out soft areas of subgrade not capable of compaction in place. Backfill with excavated material suitable for compaction.

3.6 TOLERANCES

A. Top Surface of Subgrade: Plus or minus 1/10 foot from required elevation.

3.7 FIELD QUALITY CONTROL

A. Perform compaction testing of graded material in accordance with ASTM D6938 at a frequency of 1 test per 2,000 cu yd.

B. Failure to Meet Specified Requirements: If tests indicate that specified requirements have not been achieved or cannot be obtained with equipment in use or procedure being followed, remove and replace work and modify operations so that the equipment and procedures will produce the required results. Additional testing required by ENGINEER will be to CONTRACTOR's account.

END OF SECTION

SECTION 02372

RIPRAP

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnishing and placing riprap in accordance with the locations and thicknesses shown on the Drawings.

1.2 REFERENCES

A. ASTM International (ASTM):

1. C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

2. C127 - Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.

3. C666 - Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.

1.3 PROGRESS SUBMITTALS

A. Material Source: Inform ENGINEER of proposed source of riprap at least 14 days prior to commencing production, including any change in material source during performance of the Works.

1.4 ENVIRONMENTAL REQUIREMENTS

A. Suspend operations whenever climatic conditions, as determined by ENGINEER, are unsatisfactory for placing riprap to the requirements of this Section.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, handle, and transport riprap at all times in a manner and with equipment that will prevent intermixing of riprap types, segregation, or contamination.

B. Stockpile riprap on the Site in locations approved by ENGINEER.

C. Minimize stockpiling requirements. Transport riprap from source directly to final position where possible.

D. Exercise care in loading, hauling, and unloading riprap to prevent crushing and splitting that would lead to rejection.

PART 2 PRODUCTS

2.1 MATERIALS

A. Durable field or quarry stone that is sound, hard, dense, resistant to action of air and water, and free from seams, cracks, or other structural defects.

B. Stone pieces will have a D50 of approximately 9 inches, and will be round in shape. No stones will be less than 3 inches in diameter, and no stones will be greater than 15 inches in diameter.

C. Rock Quality:

1. Absorption: ASTM C127, 2 percent maximum water absorption.

2. Soundness: ASTM C88, 15 percent maximum loss at 5 cycles.

3. Freeze Thaw: ASTM C666, 12 percent maximum loss at 35 cycles.

PART 3 EXECUTION

3.1 PREPARATION

A. Excavate to the lines and grades required for placement of the riprap.

B. Place Geotextile Filter over areas to receive riprap in accordance with Section 02076.

3.2 PLACEMENT

A. Minimum thickness of riprap layer is 24 inches.

B. Place riprap to the limits shown on the Drawings, and to within a 3-inch tolerance for thickness.

C. Place riprap with care so no damage is done to Geotextile Filter. Do not drop riprap from a height greater than 12 inches.

D. Place riprap from the base of the slope upward. Place smaller sized stones to fill voids between the larger sized stones.

END OF SECTION

SECTION 02377

GEOWEB®

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Geoweb® system for access road construction.

1.2 REFERENCES

A. ASTM International (ASTM):

1. E41 – Terminology Relating to Conditioning.

2. D4873 - Standard Guide for Identification, Storage and Handling of Geotextile.

B. Michigan Department of Transportation (DOT).

C. U.S. Army Corps of Engineers - Technical Report GL-86-19, Appendix A.

1.3 SYSTEM DESCRIPTION

A. Cellular confinement system consists of geocell material into which specific infill materials are placed. Geocell material is a polyethylene sheet strip assembly, connected by a series of offset, full-depth, ultrasonic welded seams aligned perpendicular to longitudinal axis of strips which, when expanded, form walls of a flexible, 3-dimensional, cellular confinement system.

1.4 PROGRESS SUBMITTALS

A. Material Source: Inform ENGINEER of proposed source of Geoweb® at least 14 days prior to commencing production, including any change in material source during performance of the Works.

B. Samples: Submit a representative sample no later than 10 days prior to ordering.

C. Product Data: Submit no later than 10 days prior to ordering. Include manufacturer's shop drawings including section layout, direction of expansion, tendon locations, and anchor stake locations.

D. Manufacturer's Installation Instructions: Submit at least 14 days prior to installation. Include installation, handling, storage, and repair instructions.

E. Manufacturer's Certification: Submit manufacturer's certification of polyethylene used to make geocell material. Include:

1. Manufacturer's certification of percentage of HALS.

2. Resin manufacturer's certification of polyethylene density and ESCR.

F. Installer Qualifications: Submit qualifications of installer stating installer is experienced in the installation of the specified products.

1.5 CLOSEOUT SUBMITTALS

A. Warranties: Completed original warranty forms filled out in OWNER's name and registered with manufacturer.

1.6 QUALIFICATIONS

A. Installer: Company specializing in performing the work of this Section with minimum 3 years documented experience.

1.7 PRE-INSTALLATION MEETING

A. Convene 1 week prior to commencing installation of Geoweb®.

B. Purpose of meeting is to:

1. Define Site-specific quality control and monitoring procedures.

2. Discuss pre-installation submittals.

3. Identify daily schedule.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store materials in accordance with manufacturer's instructions, out of direct sunlight

B. Notify ENGINEER 3 days in advance of delivery to the Site. Perform joint inspection with ENGINEER upon delivery. Defects or damage from shipping and handling will be grounds for rejection of a portion of Geoweb® at the discretion of ENGINEER. If rejected, remove material from the Site and replace with new material.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Install Geoweb® in accordance with manufacturer's instructions.

B. Suspend operations whenever climatic conditions, as determined by ENGINEER, are unsatisfactory for placing Geoweb® to the requirements of this Section.

1.10 MANUFACTURER'S WARRANTY

A. Provide 5-year manufacturer's warranty.

B. Fill out original warranty forms in OWNER's name and register with manufacturer.

PART 2 PRODUCTS

2.1 GEOWEB® SYSTEM

A. Assembly of HDPE sheet strips connected in series at offset, full-depth ultrasonic seams, aligned perpendicular to the longitudinal axis of the strips. When expanded, the interconnected strips form the walls of a flexible 3-dimensional cellular confinement structure into which the specified infill materials can be placed.

B. System includes perforated Geoweb® geocells (4 inches deep), ATRA® Clips, and ATRA® GFRP anchors (36-inch rebars).

2.2 GEOTEXTILE

A. Section 02074.

2.3 INFILL MATERIAL

A. Coarse aggregate, Michigan DOT Size No. 22A.

2.4 SOURCE QUALITY CONTROL

A. Manufacturer Quality Control: Perform quality assurance as follows:

1. Cell seam strength shall be uniform over the full depth of the cell. Short-term peel strength shall be tested in accordance with U.S. Army Corps of Engineers Technical Report GL-86-19, Appendix A. Minimum seam peel strengths shall be 225 pounds for the 4.0-inch depth cell.

2. Seam hang-strength test shall be performed for a period of 30 days minimum at room temperature. Room temperature is defined in ASTM E41. Test samples shall be made by welding two 4-inch wide polyethylene strips together. A test sample consisting of two carbon black stabilized strips shall support a 160-pound load for the test period. A test sample consisting of carbon black stabilized strip and a HALS stabilized strip shall support a 140-pound load for the test period.

PART 3 EXECUTION

3.1 EXAMINATION

A. Do not place Geoweb® over frozen or spongy subgrade surfaces.

B. Confirm geotextile placed in conformance with manufacturer's instructions.

C. Verify that Site conditions are as shown on the Drawings.

D. Verify that layout of the proposed work is in accordance with the Drawings.

3.2 SUBGRADE PREPARATION

A. Shape the subgrade to the grades and dimensions shown on the Drawings. Depressions in the subgrade shall be infilled with approved fill and compacted in accordance with Section 02316. Soils which are highly saturated, highly compressible, or unstable shall not be used as fill.

B. Proofroll and examine the subgrade to ensure that it meets minimum strength requirements. Remove unacceptable materials and replace with approved fill compacted in accordance with Section 02316.

3.3 PLACEMENT OF GEOTEXTILE

A. Place geotextile in accordance with Section 02074. Overlaps between adjacent sections of geotextile shall be a minimum of 18 inches or as directed by ENGINEER. The outer edge of the geotextile shall be buried a minimum of 6 inches below finished subgrade throughout the entire perimeter of the designated area in order to prevent the uncontrolled flow of surface runoff below the geotextile.

3.4 PLACEMENT AND ANCHORING OF GEOWEB® SECTIONS

A. Tendoned Geoweb® Sections:

1. Pre-cut lengths of tendon material shall be fed through the aligned holes in the cell walls of the Geoweb® strips prior to expanding individual sections into position.

2. Geoweb® sections shall be expanded uniformly into position over the geotextile as shown on the Drawings. The orientation of expanded sections shall be as directed by ENGINEER. Accommodation of non-linear alignments may require non-uniform expansion of individual Geoweb® sections in order to form tapered or curved elements. When fully expanded, the individual cells of each Geoweb® section shall measure 9.6 by 8 inches.

3. The edges of adjacent sections of Geoweb® shall be inter-leafed or butt-jointed according to which side-wall profiles abut. In all cases, the upper surfaces of adjoining Geoweb® sections shall be flush at the joint. Interleaf side connections between expanded Geoweb® sections. Welded edge seams should be overlapped and aligned when stapling. Abut end connections between Geoweb® sections. The longitudinal centerlines of abutting external cells should be aligned and stapled at the cell wall contact point.

4. Adjoining sections shall be stapled together using a Stanley Bostitch S32SL modified pneumatic stapler and 1/2-inch SL 5035 staples or a Stanley Bostitch P50-10B pneumatic stapler using 1/2-inch SB 103020 wire staples (or other approved stapler and staples).

5. Refer to manufacturer's standard drawings for additional details regarding panel connections.

B. Crest Anchorage: The Geoweb® system shall be anchored at the crest of the slope and expanded down the slope surface.

C. Anchor Systems:

1. ATRA Anchors Engaged to Tendons: The Geoweb® sections shall be permanently anchored with the specified stake anchors in the prescribed pattern. At each anchor location, use the prescribed knot to tie the tendon around the ATRA Anchor and drive the stake until the ATRA Clip is in contact with the ground surface. The tendon and stake anchor layout shall be as shown on manufacturer's standard drawings.

2. ATRA Clips Tied to Tendons: The Geoweb® sections shall be permanently anchored with the specified ATRA Clips in the prescribed manner. At each tendon restraint location, engage the ATRA Clip to the tendon using the prescribed knot and pull the tendon toward the top of the slope to ensure that the ATRA Clip bears against the cell wall. The tendon and ATRA Clip layout shall be as shown on manufacturer's standard drawings.

3.5 TOLERANCES

A. Maximum Variation from Finished Elevation: Plus or minus 0.3 foot.

B. Maximum Variation from True Alignment: Plus or minus 0.5 foot.

END OF SECTION

SECTION 02506

LANDFILL GAS VENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Landfill gas vents.

1.2 REFERENCES

A. ASTM International (ASTM): D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

1.3 PROGRESS SUBMITTALS

A. Shop Drawings: Indicate vent riser connection details from slotted screen pipe sections to solid piping section; cover/vent seal details and pipe connections to above-grade piping.

B. Product Data: Submit manufacturer's data sheets for pipe materials. Submit soil strip drain data no later than 14 days prior ordering. Include installation, handling, storage, and repair instructions.

C. Field Reports: Within 7 days of completion of the vent installation, submit soil logs, completion reports, locations, and other measurements.

1.4 CLOSEOUT SUBMITTALS

A. Record Documents: Indicate actual locations of vents, depth of vent, subsoil data, and notes regarding drilling difficulties or installation problems.

1.5 SEQUENCING AND SCHEDULING

A. Conduct landfill gas vent installation after placement of grading and bedding soil layers in the area of the gas vent, but prior to placing cap layers.

B. Make provisions for placing excavated or augered waste cuttings below the cap system in the sequence of construction.

PART 2 PRODUCTS

2.1 BELOW-GROUND VENT PIPE

A. ASTM D1785 Schedule 80, PVC, 4 inch diameter.

B. Pipe Connections: Solvent weld.

C. Pipe: Perforated and non-perforated.

D. Perforations: Drilled 1/4-inch holes, 4 rows, spaced at 4 inches and staggered along pipe.

E. End Cap: Schedule 80 PVC.

2.2 ABOVEGROUND RISER PIPE

A. ASTM D1785 Schedule 80, PVC, 4 inch diameter.

B. Pipe Connections: Solvent weld.

C. Pipe: Non-perforated.

D. Pipe Fittings: ASTM D1785 Schedule 80, PVC, 4 inch diameter.

2.3 PEA GRAVEL

A. Washed,3/4-inch clear stone.

2.4 BENTONITE GROUT

A. Mixture of Volclay or Benseal; ratio of 2.1 pounds of bentonite with 1 U.S. gallon of water to yield a minimum density of 9.4 pounds per U.S. gallon.

2.5 BENTONITE PELLET SEAL

A. Selected by CONTRACTOR for the purpose intended and subject to ENGINEER's approval prior to use.

2.6 CONCRETE

A. Capable of reaching compressive strength of 3,000 psi upon curing for 28 days.

2.7 GROUND COVER

A. Two layers of 6-mil plastic sheets under 3/4-inch plywood and covering an area not less than 8 feet by 8 feet for temporary storage of drill cuttings and/or excavated materials.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that all required safety provisions necessary to perform the Works are in place and have been tested.

B. Verify that surfaces and the Site conditions are ready to receive work.

C. Verify that the Site conditions will support equipment for performing drilling and/or excavating operations.

D. Do not commence drilling and/or excavating until ENGINEER has inspected location of each vent.

3.2 PREPARATION

A. Prevent contamination of ground surface from downhole material.

B. Ensure drill cuttings and/or excavated materials do not contact completed or finished surfaces.

C. Collect drill cuttings and/or excavated materials on the ground cover.

D. Equipment Cleaning:

1. Upon mobilization to the Site and prior to commencing drilling or excavating, thoroughly clean drill rig and associated equipment with a high-pressure, low-volume, hot water wash to remove mud and other foreign matter to the satisfaction of ENGINEER.

2. ENGINEER will inspect equipment to ensure that mud, oil, grease, and hydraulic fluid have been removed, seals and gaskets are intact, and no fluids are leaking.

3. Make any and all repairs noted by ENGINEER.

4. Clean equipment using dry methods prior to mobilizing between vent locations.

5. Perform decontamination and cleaning to the satisfaction of ENGINEER.

3.3 BOREHOLES

A. Drill boreholes to install landfill gas vents as shown on the Drawings. Continue borehole until refuse is encountered.

B. If confining layer (i.e., clay) is encountered, continue borehole to a minimum of 3 feet beyond the confining layer into permeable soils, or to a maximum of 10 feet into the confining layer, and install perforated riser to bottom of borehole.

C. Log each gas vent borehole to the specified depth. Include, at a minimum, the following information:

1. The location and designation of the vent.

2. The general character and type of material encountered.

3. The depth at which the water level stands if encountered.

4. Completed depth of boring.

3.3 LANDFILL GAS VENTS

A. Clean borehole of loose material.

B. Construct vent in accordance with the details shown on the Drawings.

C. Lower pipe into hole to the elevation shown on the Drawings and keep vertical and in place.

D. Place pea gravel in a manner that does not damage or disturb the pipe.

E. Place bentonite pellet seal on the pea gravel to prevent fines from migrating into the pea gravel.

F. Place bentonite grout and protective concrete collar to the thickness as shown on the Drawings.

G. Place VFPE boot seal over vent rise and attach to synthetic cover in accordance with manufacturer's instructions and seal to vent riser.

H. Provide sufficient height to extend gooseneck beyond normal snowfall.

I. Survey final locations of vents.

J. Maintain landfill cap system during and after installation of landfill gas vents.

3.4 DISPOSAL OF PROTECTIVE GROUND COVER

A. Plastic and plywood sheeting used as ground cover may be swept clean at each working location and reused at subsequent locations, provided such cover is intact and not damaged.

B. Upon completion of vent installations and/or abandonments, dispose of plastic sheeting and plywood with spent personal protective equipment as solid waste to an off-Site landfill approved by ENGINEER.

3.5 TOLERANCES

A. Landfill Gas Vents Maximum Variation from True Position Plumb: 0.25 inch.

3.6 FIELD QUALITY CONTROL

A. ENGINEER will inspect for integrity of bentonite seal vent/cover seal.

3.7 PROTECTION OF FINISHED WORK

A. Ensure protection of installed vent during installation of cover systems adjacent to vent.

END OF SECTION

SECTION 02911

TOPSOIL

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnishing and placing Topsoil, as shown on the Drawings.

1.2 REFERENCES

A. ASTM International (ASTM):

1. D422 - Standard Test Method for Particle Size Analysis of Soils.

2. D2974 - Standard Test Method for Moisture, Ash and Organic Matter of Peat and Other Organic Soils.

3. D4972 - Standard Test Method for pH of Soils.

B. United States Environmental Protection Agency (USEPA): SW 846 Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, Third Edition and Promulgated Updates I III, November 1986.

1.3 PROGRESS SUBMITTALS

A. Test Results: At least 14 days prior to commencing transport to the Site, submit test results of imported topsoil. Indicate, by test results, information necessary to determine suitability, including, but not limited to, organic content, pH, phosphorus, potassium, calcium, and magnesium; and laboratory or supplier recommendation for fertilizer application rate for specified seed mixture.

PART 2 PRODUCTS

2.1 MATERIALS

A. Natural loam, sandy loam, silty loam or clay loam humus-bearing soils of mineral origin adapted to the sustenance of plant life.

B. Free from refuse, subsoils, contamination, materials toxic to plant growth, and foreign objects.

C. A pH of 5.0 to 7.5, determined in accordance with ASTM D4972. Add sufficient limestone to bring pH to range of 5.0 to 7.5.

D. Containing minimum 2 percent and maximum 10 percent organic matter determined in accordance with ASTM D2974.

E. Capable of supporting growth of grass.

F. Obtain topsoil from a well-drained site that is free of flooding.

2.2 SOURCE QUALITY CONTROL

A. Testing and Analysis of Topsoil:

1. Particle Size, ASTM D422: 1 sample per 2,000 cu yd, or portion thereof, of topsoil required.

2. pH, ASTM D4972: 1 sample per 2,000 cu yd, or portion thereof, of topsoil required.

3. Organic Matter, ASTM D2974: 1 sample per 2,000 cu yd or portion thereof, of topsoil required.

4. Phosphorus, potassium, calcium, and magnesium, in accordance with state accredited method: 1 sample per 2,000 cu yd, or portion thereof, of topsoil required.

5. Chemical Analysis: 1 sample per source. In accordance with Paragraph 2.2 B.

B. Chemical characterization in the laboratory in accordance with the following methods:

Parameter	*Extraction/Preparation*[(1)]	*Analysis*[(2)]
TCL(2) Volatile Organic Compound	5035	8260B
TCL Semi Volatile Organic Compound	3540C/3550B	8270C
Pesticide	3540C/3550B	8081A
PCB	3540C/3550B	8082
Herbicides	3540C/3550B	8151A
TAL(3) Metals	3050B or 3051	6010B/7000 Series
Cyanide	013	9010 or 9012A

Notes:

(1) USEPA SW 846.
(2) TCL Target Compound List.
(3) TAL Target Analyte List.

C. If tests indicate materials do not meet specified requirements, change material or material source and retest.

D. Provide materials of each type from the same source throughout the Works.

E. In the event of changes to approved sources of materials during the performance of the Works, immediately advise ENGINEER of revised locations and obtain approval of such locations and materials prior to use in the Works.

PART 3 EXECUTION

3.1 PREPARATION

A. Remove vegetation, foreign materials, unsatisfactory or contaminated soils, obstructions, and matter harmful to plant growth from ground surface before placement.

B. Prepare subsoil to eliminate uneven areas and low spots. Maintain lines, levels, profiles and contours. Make changes in grade gradual. Blend slopes into level areas.

C. Scarify subsoil to a depth of 3 inches where Topsoil is to be placed. Repeat cultivation in areas where equipment used for hauling and spreading Topsoil has compacted subsoil.

3.2 PLACEMENT

A. Place Topsoil to a uniform depth of 6 inches.

B. Finish grade to within +0.10 foot of elevations shown on Drawings.

C. Break down clods and lumps.

END OF SECTION

SECTION 02921

SEEDING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Preparing the Topsoil.

B. Seeding.

C. Hydroseeding.

D. Mulching.

E. Maintenance for seed establishment.

1.2 REFERENCES

A. Official Seed Analysis of North America.

1.3 DEFINITIONS

A. Weeds: Includes, but is not limited to, Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.4 PROGRESS SUBMITTALS

A. Seeding and Erosion Control Plan: At least 14 days prior to placing topsoil, submit to ENGINEER for approval CONTRACTOR's Seeding and Erosion Control Plan including, but not limited to, the following:

1. Seed mixture(s) and fertilizers for the Site and application rates.

2. Time of year for planting such mixtures.

3. Methods of preparing seedbed, seeding, sodding, rolling seeded and sodded areas, and irrigation.

4. Methods to provide erosion control until seed is placed and grass is established (i.e., use of any or a combination of emulsifiers, tackifiers, mulches, adhesives, nurse crop seed, and erosion control matting or blankets).

B. Seed Certificates: At least 14 days prior to seeding submit certificates from seed vendors for each seed mixture required, stating botanical and common name, percentage by weight and percentages of purity, germination, and weed seed for each species.

C. Fertilizer Certificate: At least 14 days prior to placing fertilizer, submit certificate confirming conformance with specification.

D. Erosion Control Blanket: At least 14 days prior to delivering erosion control blanket, submit manufacturer product data and delivery, handling, storage, installation, and repair methods.

1.5 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

B. Seed which is wet, moldy, or otherwise damaged is not acceptable.

1.7 ENVIRONMENTAL REQUIREMENTS

A. Do not apply materials over snow, ice, frozen ground, or standing water.

B. Do not apply seed slurry when wind conditions are such that material would be carried beyond designated area or that materials would not be uniformly applied.

1.8 SEQUENCING AND SCHEDULING

A. Schedule topsoil placing to permit seeding operations under optimum conditions during normal planting seasons. The permanent seed mix shall be applied only between March 1 and June 15, and between September 1 and October 10, or as approved by ENGINEER.

B. Coordinate planting with specified maintenance periods to provide maintenance until acceptance by ENGINEER.

C. Seed areas within 10 days of completion of topsoiling.

D. Apply fertilizer at least 1 week after application of lime, if lime is required.

PART 2 PRODUCTS

2.1 SEED MIXTURE

A. Seed Mixture:

1. Cover crop of winter rye (Secale cerale) at 60 lbs/acre and 5 lbs per acre of timothy (Phleum pratense).

2. Prairie grasses:

a. Canada wild rye (Elymus Canadensis) at 5 lbs/acre

b. Switch grass (Panicum virgatum) at 10 lbs/acre

c. Big Blue stem (Andropogon gerardii) at 10 lbs/acre

d. Indian grass (Sorghastrum nutans) at 10 lbs/acre

3. Prairie forbs:

a. Black eyed susan (Rudbeckia hirta) 8 ounce/acre

b. Yellow cone flower (Ratiba pinnata) 8 ounce/acre

c. Bergamot (Monarda fistulosa) 4 ounce/acre

d. Smoot blue aster (Aster laevis) 4 ounce/acre

e. False sunflower (Heliopsis helianthoides) 4 oz/acre

f. Beardtongue (Penstemon digitalis) 2 oz/acre

g. Butterfly milkweed (Asclepias tuberosa) 2 oz/acre

h. Stiff goldenrod (Solidago rigida) 2 oz/acre

i. Sky blue aster (Aster azureus) 2 oz/acre

j. Rosin weed (SlIphium integrifolium 2 oz/acre

k. Spiderwort (Tradescantia ohiensis) 4 oz/acre

l. Wild lupine (Lupinus perennis) 4 oz/acre

m. Sand coreopsis (Coreopsis lanceolata) 2 oz/acre

n. Hoary vervain (Verbena stricta) 4 oz/acre

Note: All the prairie and wetland seed should come from sources within a 300-mile radius of the landfill.

B. Grass Seed: Fresh, clean, new crop seed harvested previous year complying with the tolerance for purity and germination established by Official Seed Analysis of North America; minimum germination of 75 percent and minimum purity 97 percent; obtained from an approved seed house.

C. Weed Seed Content: Not over 0.25 percent and free of noxious weeds.

2.2 ACCESSORIES

A. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.

B. Water: Clean, fresh, and free of substances or matter which could inhibit vigorous growth of grass.

C. Lime (if required based on topsoil analysis): Ground agricultural limestone, minimum 85 percent of total carbonates graded as follows:

Percent Passing By Weight	*Sieve Size*
90	No. 18
50	No. 120

D. Erosion Control Agent:

1. RESYN® 5792 polyvinyl acetate.

2. The dried film after application shall conform to the following requirements:

   1. Solids: 55 percent.

   2. Viscosity: 2,000 to 10,000 centipoises.

   3. pH: 4 to 5.

   4. Specific Gravity: 1.04.

   5. Particle Size: 0.5 to 3 microns.

   6. pH: Less than 4.

   7. Freeze Thaw Stability: To minus 5 degrees C.

PART 3 EXECUTION

3.1 INSPECTION

A. Verify that prepared soil base is ready to be seeded.

3.2 PREPARATION OF TOPSOIL

A. Grade Topsoil to finish grades to ensure positive drainage.

B. Remove stones or objects over 2 inches in diameter, foreign materials, weeds, and undesirable plants and their roots. Remove contaminated topsoil.

C. Apply fertilizer immediately before seeding in accordance with Section 02923.

3.3 SEEDING

A. Apply seed at a-rates prescribed above with a seed drill.

B. Planting Season: March 1 to June 15 and September 1 to October 10, or as approved by ENGINEER.

C. Do not sow immediately following rain, or when ground is too dry or too wet, or during windy periods.

3.4 MULCHING

A. Apply mulch to the seeded area at a rate of 2 tons per acre. Use straw mulch, unless otherwise recommended.

B. Immediately following mulching, roll mulched area. On large areas, a cultipacker may be used to roll and cover the seed.

3.5 WATERING

A. Apply water with a fine spray immediately after each area has been mulched. Saturate soil to a depth of 4 inches.

B. Keep the surface layer of soil damp by frequent light watering with a fine spray during the germination period when rainfall is insufficient.

3.6 OVERLAP

A. Seeding, temporary cover, and erosion control blanket shall overlap adjoining vegetation by 12 inches.

3.7 MAINTENANCE FOR SEED ESTABLISHMENT

A. Start maintenance immediately after area seeded.

B. Maintain seeded area for not less than the period stated below and longer, as required to establish an acceptable stand, as determined by ENGINEER:

1. Not less than 60 days after last area seeded.

2. If planted in fall and not given full 60 days of maintenance, or if not considered acceptable by ENGINEER at completion of 60 days continue maintenance the following spring until acceptable vegetative cover is established.

C. Maintain vegetative cover by watering, fertilizing, weeding, overseeding, and other operations such as regrading and replanting as required to establish a smooth, acceptable grassed surface, free of eroded or bare areas.

D. Provide and maintain temporary piping hoses and watering equipment as required to convey water from water sources and to keep grassed areas uniformly moist as required for proper growth.

E. Vegetative cover will be accepted by ENGINEER provided all requirements have been complied with, including completion of 60 day maintenance period, and the following.

1. Vegetative cover is properly established.

2. Turf is free of eroded, bare, or dead spots and 98 percent free of weeds.

3. No surface is visible when vegetative cover has been cut to a height of 4 to 5 inches.

F. Immediately re seed areas which show signs of bare spots.

3.8 CLEANING

A. Clean up immediately, soil, mulch, or other debris spilled onto pavement and dispose of deleterious materials.

B. Take precautions and prevent contamination by seeding and mulching slurry of structures, signs, guardrails, fences, utilities, or other surfaces not specified to be landscaped.

C. Where contamination occurs, remove seeding slurry to satisfaction of, and by means approved by ENGINEER.

3.9 PROTECTION OF FINISHED WORK

A. Protect landscaped areas from damage.

END OF SECTION

APPENDIX G

SURFACE WATER MANAGEMENT CALCULATIONS

- Replacement for January 2009 Pre-Final Design Report Appendix

CONESTOGA-ROVERS
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MEMORANDUM

TO:	Rick Hoekstra	REF. NO.:	056393
FROM:	Stacy Burke, Paul Farquharson/smc/2	DATE:	June 16, 2009
C.C.:	Greg Carli		
RE:	**Storm Water Design to Support Remedial Action 12th Street Landfill, Operable Unit No. 4 Applied Paper, Inc/Portage Creek/Kalamazoo River Superfund Site Otsego, Michigan**		

1.0 SUMMARY

A hydrologic model was completed for the storm water design at the 12th Street Landfill site in Otsego Township, Michigan. The storm water ditches were designed to convey the 24-hour/25-year storm event, with additional modeling completed for the 24-hour/100-year storm events.

2.0 HYDROLOGIC MODELING

The storm water design for the 12th Street Landfill site was conducted by applying single-event design storms. Single-event hydrologic modeling applies synthetic design storm events to the Site under various conditions to quantify the peak runoff rates and volumes. The synthetic design storm events were developed by applying the SCS Type II rainfall distribution to known rainfall depths for various return periods of a 24-hour duration storm event with a 5 minute time step. The historical climatic data was obtained from Technical Paper 40, *Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 years (1961)* A summary of the rainfall depths representing the 25-year and 100-year design storm events is presented in Table 1.

The PCSWMM.net model (SWMM v.5.0.013) was used to calculate flows at all ditch inlet locations for both the 25-year and 100-year storm events. The model is a widely accepted hydrologic and hydraulic computer-modeling program based on the United States Environmental Protection Agency's Stormwater Management Model (SWMM).

To implement the hydrology modeled, the landfill was subdivided into a number of subcatchments, each of which has internally similar characteristics for slope, hydraulic roughness and infiltration and other aspects related to runoff. Flow from each subcatchment is either directed overland to a neighboring subcatchment or into a ditch, modeling the manner in which runoff will flow across the landfill.

Subcatchment areas were delineated based on existing conditions as shown on Figure 1. A total of twenty-six catchments were delineated based on the final proposed grading plan. Figure 2 illustrates the flow schematic.

Infiltration was estimated using the Horton Method (Horton, 1940) as implemented in SWMM. Infiltration parameters and decay rates used in the model explicitly were calculated based on conservative past landfill designs/soil parameters. Typical parameters for these soil types were used to estimate infiltration rates. Input parameters used in the model are presented in Table 2.

3.0 STORM WATER DITCHES/PERIMETER ROAD

The storm water ditches were sized initially to convey the 24-hour/25-year storm event. However, they will also be able to convey the 24-hour/100-year storm event. For efficiency, the perimeter access road and ditches have been integrated, which resulted in the dimensions of the road/ditch with a five-foot bottom width with 3H:1Vside slopes. The bottoms of the ditches were modeled to include a stone bottom to protect from damage associated with vehicular traffic (ATV's for sampling, etc.).

The ditch outlets consist of depressions approximately every 200 feet along the outside perimeter of the ditch(es) with the complete outside perimeter along the northern section of the landfill armored with a turf reinforcement mat to protect against erosion. All of these outlets will discharge to the wetland, discharging to the Kalamazoo River.

Model outputs are provided in Tables 3 to 5.

TABLE 1

STORM EVENTS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

Return Event	*Total Rainfall Depth* [1,2] *(inches)*
25-year	4.50
100-year	5.50

Notes:

1 Rainfall depths determined from Technical Paper 40.

2 Generated hyetograph for PCSWMM model assumes a Soil Concervation Service (SCS) Type II Storm Event Distribution.

TABLE 2

SUBCATCHMENT PARAMETERS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

Subcatchment No.	*Downstream Junction No.*	*Width*	*Area*	*Percent Impervious*	*Slope*	*Manning's 'n'*		*Depression Storage*			*Infiltration*	
						Imperv	*Perv*	*Imperv*	*Perv*	*Max. Rate*	*Min. Rate*	*Decay Rate*
		(ft)	*(ac)*	*(ft/ft)*	*(%)*			*(in)*	*(in)*	*(in/hr.)*	*(in/hr.)*	*(1/sec)*
C1	J9	58	0.16	0	6.9	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C2	J1	45	0.11	0	37.4	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C3	C2	114	0.26	0	3.0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C4	J2	130	0.46	0	20.5	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C5	J3	105	0.36	0	19.8	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C6	C7	138	0.43	0	9.6	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C7	J4	51	0.24	0	29.1	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C8	C9	133	0.47	0	7.6	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C9	J5	50	0.25	0	27.0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C10	J7	48	0.16	0	4.6	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C11	J7	71	0.17	0	12.8	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C12	J6	66	0.14	0	22.8	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C13	J8	76	0.25	0	16.0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C14	J14	75	0.12	0	13.6	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C15	C13	113	0.42	0	4.9	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C16	C15	70	0.28	0	5.4	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C17	C14	41	0.10	0	4.7	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C18	J13	26	0.09	0	32.0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C19	C18	28	0.05	0	10.4	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C20	C19	56	0.26	0	6.2	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C21	J12	50	0.08	0	32.0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C22	C21	87	0.33	0	5.2	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C23	J11	30	0.11	0	40.5	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C24	C23	121	0.42	0	4.9	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C25	J10	64	0.20	0	5.9	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C26	C12	43	0.13	0	5.1	0.01	0.25	0.1	0.25	1	0.00014	0.0015

TABLE 3

CONDUIT PARAMETERS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

North Part Channel No.	*Length (ft)*	*Conduit Type*	*Manning'n*	*Bottom Width (ft)*	*Depth/Diameter (ft)*	*Junction Starts*	*Junction Ends*	*Side Slope (ft/ft)*	*Conduit slope (%)*
1	138.5	Trapezoidal Swale	0.041	5	1.50	J1	J2	3	5.8
2	86.5	Trapezoidal Swale	0.041	5	1.50	J2	J3	3	0.7
3	20.0	Trapezoidal Swale	0.041	20	1.00	J3	O1	3	2.5
4	20.0	Trapezoidal Swale	0.041	20	1.00	J4	O2	3	2.5
5	20.0	Trapezoidal Swale	0.041	20	1.00	J5	O3	3	2.5
6	20.0	Trapezoidal Swale	0.041	20	1.00	J6	O4	3	2.5
7	130.8	Trapezoidal Swale	0.041	5	1.50	J8	J7	3	0.5
8	20.0	Trapezoidal Swale	0.041	20	1.50	J7	O5	3	30.0
9	178.9	Trapezoidal Swale	0.041	5	1.50	J9	J10	3	0.5
10	123.1	Trapezoidal Swale	0.041	5	1.50	J10	J11	3	9.8
11	126.9	Trapezoidal Swale	0.041	5	1.50	J11	J12	3	5.7
12	80.8	Trapezoidal Swale	0.041	2	1.50	J12	J13	3	1.7
13	121.2	Trapezoidal Swale	0.041	2	1.50	J13	J14	3	2.8
14	20.0	Trapezoidal Swale	0.041	20	1.50	J14	O6	3	30.0

TABLE 4

SUBCATCHMENT PEAK FLOWS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

Subcatchment		*25-Year*	*100-Year*
No.	*Area (acres)*	*Peak Discharge (cfs)*	*Peak Discharge (cfs)*
C1	0.16	0.50	0.68
C2	0.11	0.96	1.43
C3	0.26	0.75	1.06
C4	0.46	1.52	2.20
C5	0.36	1.19	1.73
C6	0.43	1.35	1.87
C7	0.24	1.72	2.61
C8	0.47	1.37	1.93
C9	0.25	1.65	2.56
C10	0.16	0.43	0.62
C11	0.17	0.60	0.85
C12	0.14	0.76	1.07
C13	0.25	1.53	2.41
C14	0.12	0.65	0.91
C15	0.42	1.41	2.17
C16	0.28	0.73	1.05
C17	0.10	0.30	0.42
C18	0.09	0.61	0.97

TABLE 4

SUBCATCHMENT PEAK FLOWS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

Subcatchment No.	*Area (acres)*	*25-Year Peak Discharge (cfs)*	*100-Year Peak Discharge (cfs)*
C19	0.05	0.64	0.99
C20	0.26	0.65	0.95
C21	0.08	0.94	1.44
C22	0.33	0.87	1.26
C23	0.11	1.18	1.84
C24	0.42	1.13	1.63
C25	0.20	0.58	0.82
C26	0.13	0.37	0.53

TABLE 5

CHANNEL PERFORMANCE
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

		25-year storm event		*100-year storm event*	
	Conduit Type	*Max Flow (cfs)*	*Max Velocity (fps)*	*Max Flow (cfs)*	*Max Velocity (fps)*
1	Trapezoidal Swale	0.9	1.8	1.4	2.1
2	Trapezoidal Swale	2.4	1.3	3.4	1.4
3	Trapezoidal Swale	3.6	2.4	5.0	2.8
4	Trapezoidal Swale	1.7	1.8	2.6	2.1
5	Trapezoidal Swale	1.6	1.8	2.5	2.1
6	Trapezoidal Swale	0.8	1.3	1.1	1.5
7	Trapezoidal Swale	1.5	0.9	2.4	1.1
8	Trapezoidal Swale	2.4	2.5	3.6	3.0
9	Trapezoidal Swale	0.5	0.7	0.7	0.8
10	Trapezoidal Swale	1.0	2.2	1.5	2.5
11	Trapezoidal Swale	2.2	5.9	3.3	6.9
12	Trapezoidal Swale	3.1	2.1	4.7	2.4
13	Trapezoidal Swale	3.7	2.7	5.6	3.0
14	Trapezoidal Swale	4.2	3.5	6.4	4.1

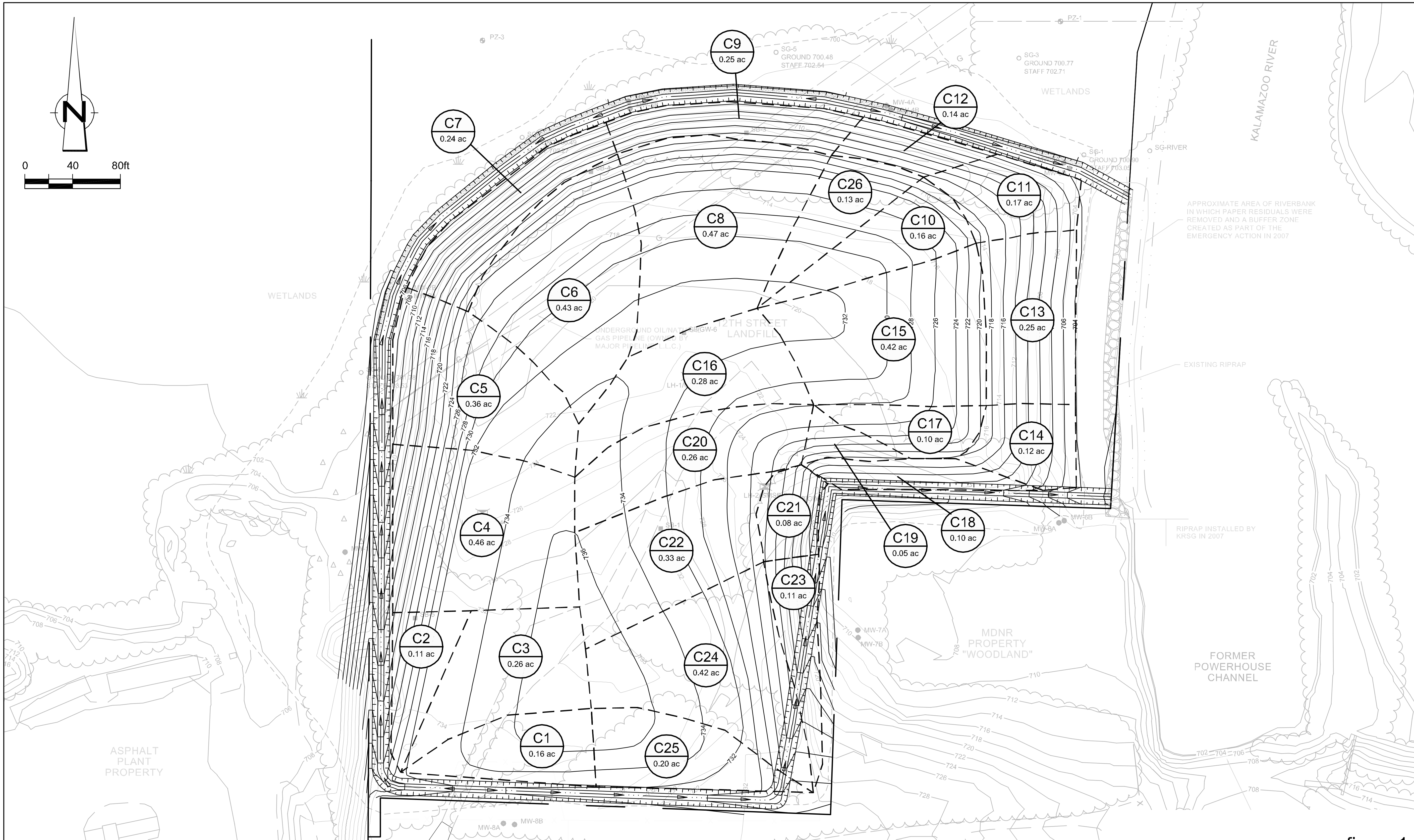


figure 1

PROPOSED CATCHMENT AREA DELINEATION
12th STREET LANDFILL
Otsego Township, Michigan

56393-05(002)GN-WA002 JUN 16/2009

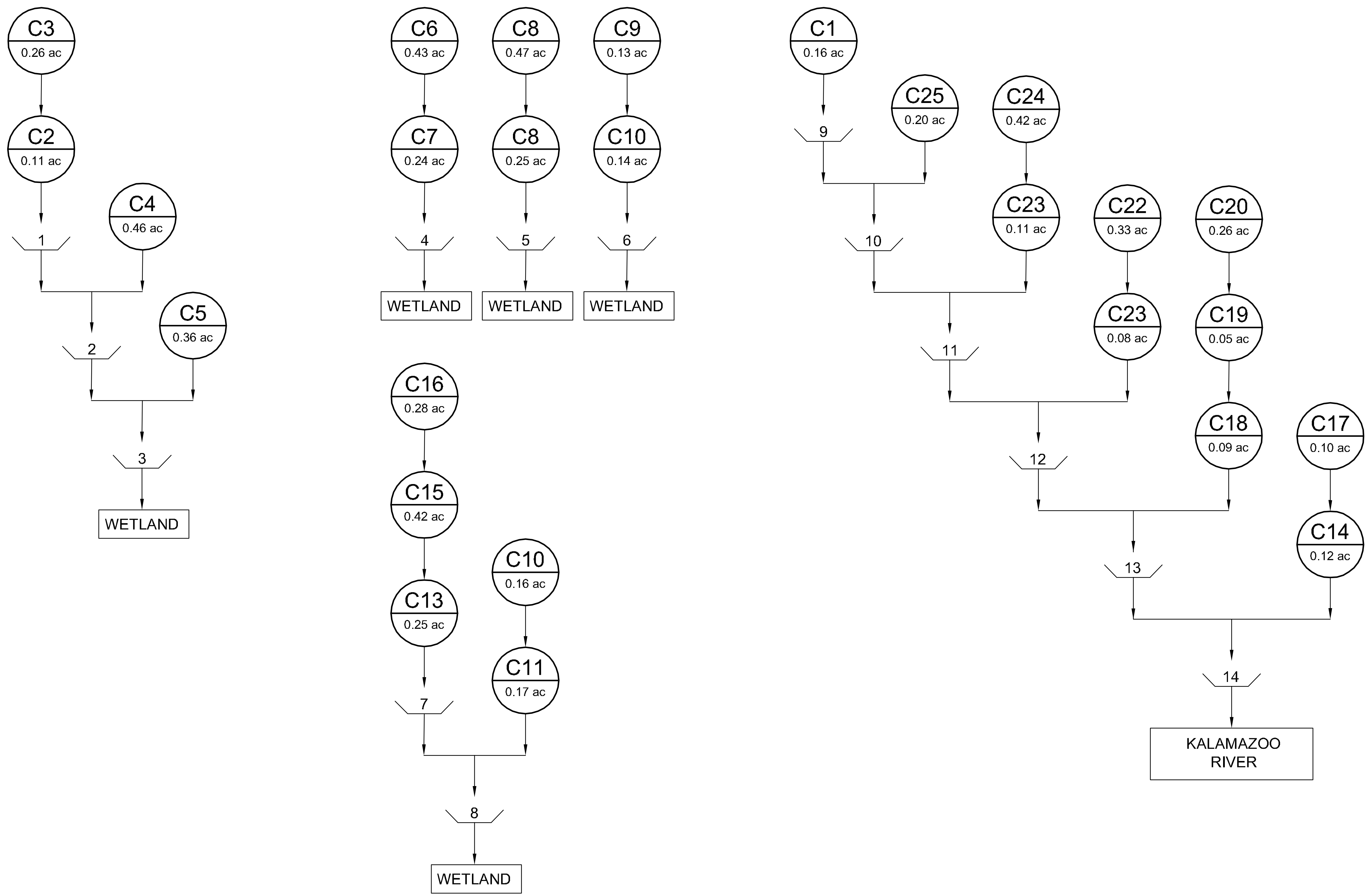


figure 2

FLOW SCHEMATIC
12th STREET LANDFILL
Otsego Township, Michigan

56393-05(002)GN-WA003 JUN 16/2009

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: Weyerhaeuser Company 56393

Project: 12 ST Landfill Location: Otsego Township, Michigan

CALCULATION IDENTIFICATION

Calculation Ref. No.: ____________ No. Pages: 13
(Including calculation cover sheet)

Calculation Description:

CAP DRAINAGE LAYER HYDRAULICS

Design: A.Wesolowski Date: May 26/09
Checked: R.Hoekstra Date: June 10/09

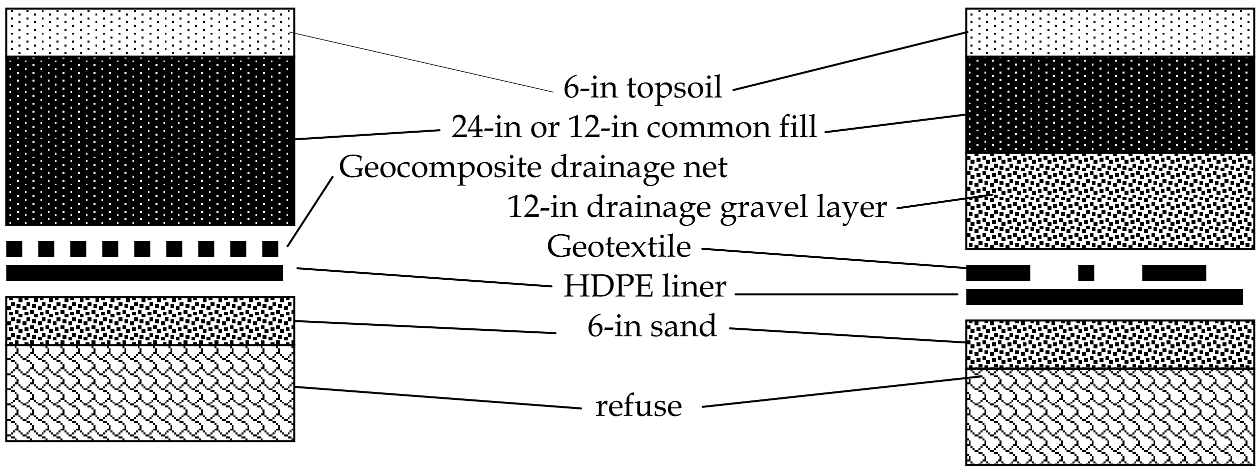
RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)
1	06/29/09					To reflect revised contour plan
2	10/19/09					Slope revision to 4:1

DRAINAGE LAYER HYDRAULICS

1.1 Data input

- two cap design options:



- common fill layer permeability: ks = 0.00001 cm/s (1×10^{-7} m/s)
- drainage gravel layer permeability: kg = 0.001 m/s

- critical path No. 2, slope segment 7% - slope length 100 ft = 30.5 m

- critical path No. 2, slope segment 25% - slope length 106 ft = 32.3 m

- reduction factors for drainage composite
  for intrusion RF_{in} = 1.5
  for creep RF_{cr} = 1.4
  for chemical clogging RF_{cc} = 1.2
  for biological clogging RF_{bc} = 1.6
  overall FS = 2
  Total Fs = 8

- criteria for Lateral Drainage for Final Cover Side Slope, Landfill Drainage System www.landfilldesign.com, Unit Gradient Method. Interactive Design Tool(see attached)

1.2 Geocomposite Drainage Net Option

1.2.1 Required transmissivity of the geocomposite Y_{req}

Required (ultimate) geocomposite transmissivities have been calculated utilizing software program , Unit Gradient Method, (see attached).

Treq = 0.000352 m2/s – for 7% segment

Treq = 0.000209 m2/s – for 25% segment

1.2.2 Available transmissivity of the geocomposite Y_{avail}

Available transmissivity for GSE Fabrinet 300 mil (2x6oz) geocomposite product, according to attached manufacturers charts for given (design) gradients and normal pressure of approximately 1000 psf at given cap design configuration.

T 7% avail = 0.0029 m2/s for 7% segment
T 25% avail = 0.0018 m2/s for 25% segment

Required (ultimate) transmissivitiy is below the available transmissivity ($Tr_{eq}<T_{avail}$).

1.2.3 Confirmatory Manual Check

Utilizing total inflow into the drainage net from both segments.

Total inflow into the drainage net equal to drainage net outflow:

Q IN = Q Outflow

where:

QIN for 7% segment based on 30.5 m length
QIN for 25% segment based on 30.5 m + 32.3 m = 62.8 m, total length

Q Outflow = T x i (in terms of transmissivity) for

-unit width of the drainage net = 1
- unit gradient = 1

T- required transmissivity
i – slope = 7% or 25%

QIN 7% segment = ks x L = 0.0000001 m/s x 30.5 m = 0.00000305 m3/s
QIN 25% segment = ks x L = 0.0000001 m/s x 62.8 m = 0.00000628 m3/s

Utilizing total factor of safety Fs = 8

8 x Q IN = Q Outflow

8 x QIN = T x i

T for 8% segment= 0.00034 m2/s
T for 33% segment = 0.00020 m2/s

Required transmissivity is below the available transmissivity.

1.2.4 Conclusion

The available transmissivity of GSE Fabrinet 300 mil product with 2 x 6 oz or 2 x 8 oz geotextile is satisfactory.

1.3 Drainage Gravel Layer Option

1.3.1 Infiltration into drainage layer

QIN 7% segment = ks x L = 0.0000001 m/s x 30.5 m = 0.00000305 m3/s
QIN 33% segment = ks x L = 0.0000001 m/s x 62.8 m = 0.00000628 m3/s

Per 1 meter width and unit gradient = 1

1.3.2 Available drainage gravel layer hydraulic capacity

Qavail 7% segment = kg x i x A = 0.001 m/s x 0.07 x (0.30 m x 1.0 m) = 0.000021 m3/s

Qavail 25% segment = kg x i x A = 0.001 m/s x 0.25 x (0.30 m x 1.0 m) = 0.000075 m3/s

1.3.3 Conclusion

The available drainage gravel layer hydraulic capacity , based on kg= 0.001 m/s material permeability is satisfactory.

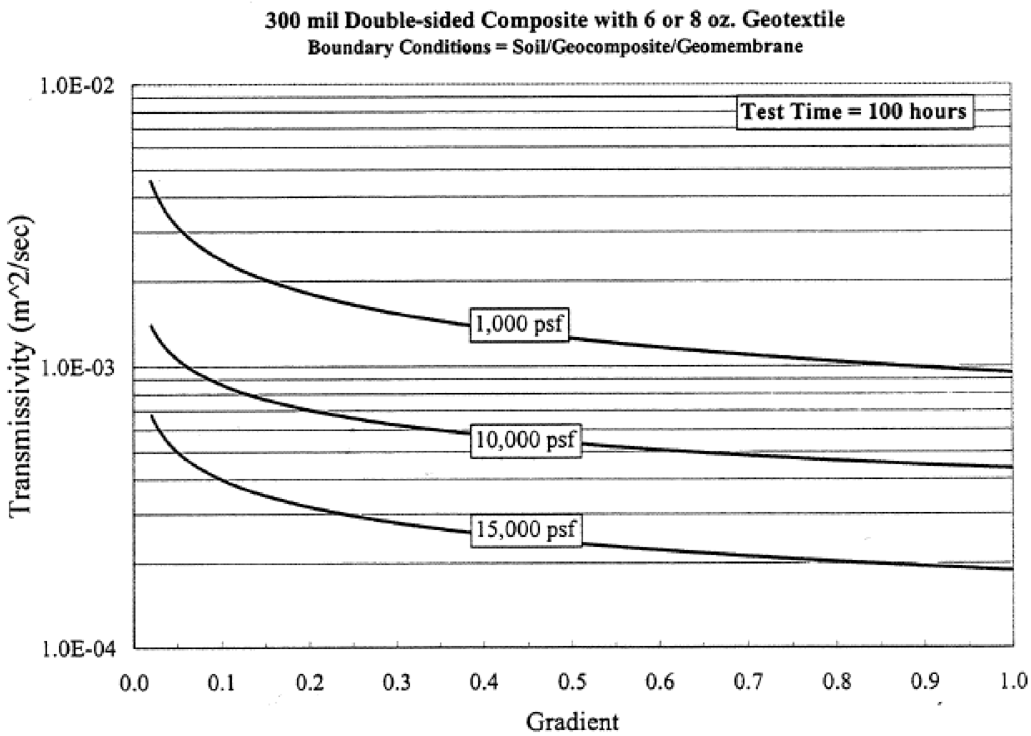


Figure A-9 100-hour transmissivity of 300 mil biplanar geonet geocomposite under soil/geocomposite/geomembrane boundary conditions.

GSE

Product Data Sheet

GSE STANDARD PRODUCTS

GSE FabriNet UF Geocomposites

GSE FabriNet UF geocomposite consists of GSE HyperNet UF geonet heat-laminated on one or both sides with a GSE nonwoven needlepunched geotextile. GSE HyperNet UF is a 300 mil thick geonet manufactured from a premium grade high density polyethylene resin. For the purpose of lamination to geonets, GSE nonwoven needlepunched geotextiles are available in mass per unit area range of 6 oz/yd² (200 g/m²) to 16 oz/yd² (540 g/m²). GSE FabriNet UF geocomposites are designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions. Index properties for the product are provided in the table below. Please contact GSE for further information regarding performance under site-specific conditions.

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE ROLL VALUE[d]		
Geocomposite			6 oz/yd²	8 oz/yd²	10 oz/yd²
Product Code:			F82060060S	F82080080S	F82100100S
Transmissivity[a], gal/min/ft (m²/sec)	ASTM D 4716-00	1/540,000 ft²	4.35 (9.0 x 10⁻⁴)	4.35 (9.0 x 10⁻⁴)	4.35 (9.0 x 10⁻⁴)
Ply Adhesion, lb/in (g/cm)	GRI GC-7	1/50,000 ft²	1.0 (178)	1.0 (178)	1.0 (178)
Roll Width, ft (m)			14.5 (4.4)	14.5 (4.4)	14.5 (4.4)
Roll Length, ft (m)			160 (48)	150 (45)	140 (42)
Roll Area, ft² (m²)			2,320 (215)	2,175 (202)	2,030 (188)
Geonet core[b]					
Transmissivity[a], gal/min/ft (m²/sec)	ASTM D 4716-00		38.64 (8 x 10⁻³)	38.64 (8 x 10⁻³)	38.64 (8 x 10⁻³)
Thickness, mil (mm)	ASTM D 5199	1/50,000 ft²	300 (7.6)	300 (7.6)	300 (7.6)
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	1/50,000 ft²	75 (13.3)	75 (13.3)	75 (13.3)
Carbon Black Content, %	ASTM D 1603	1/50,000 ft²	2.0	2.0	2.0
Geotextile (prior to lamination)[b,c]					
Mass per Unit Area, oz/yd² (g/m²)	ASTM D 5261	1/90,000 ft²	6 (200)	8 (270)	10 (335)
Grab Tensile, lb (N)	ASTM D 4632	1/90,000 ft²	170 (755)	220 (975)	260 (1,155)
Puncture Strength, lb (N)	ASTM D 4833	1/90,000 ft²	90 (395)	120 (525)	165 (725)
AOS, US Sieve (mm)	ASTM D 4751	1/540,000 ft²	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, (sec⁻¹)	ASTM D 4491	1/540,000 ft²	1.5	1.5	1.2
Flow Rate, gpm/ft² (l/min/m²)	ASTM D 4491	1/540,000 ft²	110 (4,480)	110 (4,480)	85 (3,460)
UV Resistance, % Retained	ASTM D 4355 (after 500 hours)	once per formulation	70	70	70

NOTES:

- [a]Gradient of 0.1, normal load of 10,000 psf, water at 70° F (20° C), between stainless steel plates for 15 minutes.
- [b]Component properties prior to lamination. Net thickness is a typical value.
- [c]Several geotextiles are available and may be supplied as determined by GSE.
- [d]These are MARV values and are based on the cumulative results of specimens tested by GSE. AOS in mm is a maximum average roll value.

DS066 R10/07/03

Americas	GSE Lining Technology, Inc.	Houston, Texas	800-435-2008	281-443-8564	Fax: 281-230-8650
Europe/Middle East/Africa	GSE Lining Technology GmbH	Hamburg, Germany		49-40-767420	Fax: 49-40-7674233
Asia/Pacific	GSE Lining Technology Company Ltd.	Bangkok, Thailand		66-2-937-0091	Fax: 66-2-937-0097

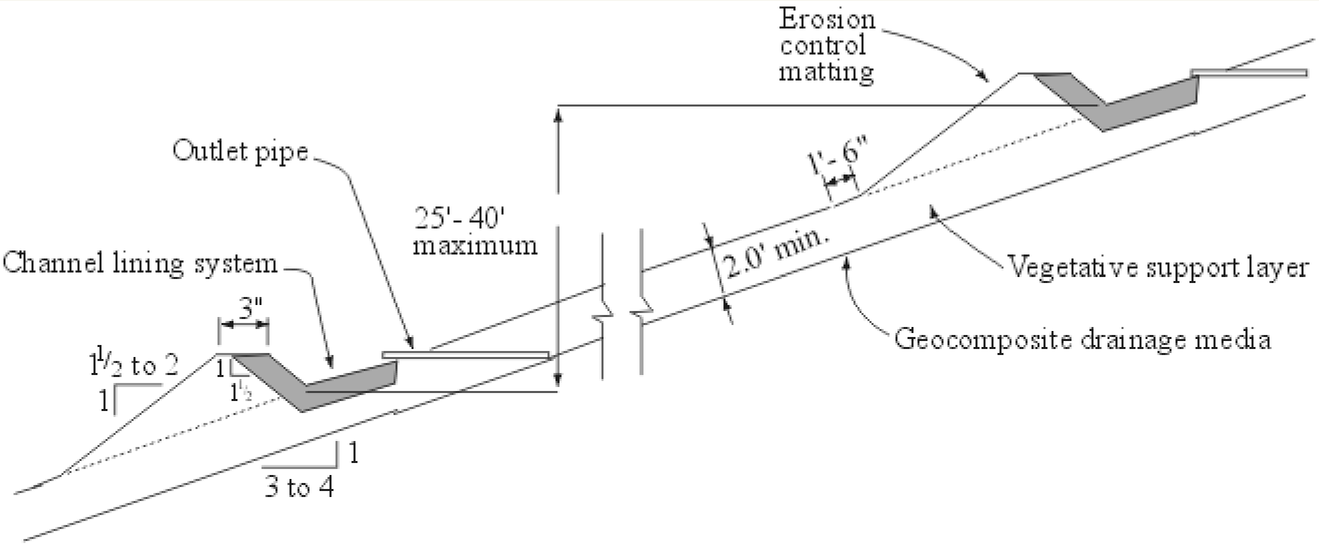
This product data sheet is also available on our website at:

www.gseworld.com

landfilldesign.com

Unit Gradient Method - Design Calculator

Problem Statement



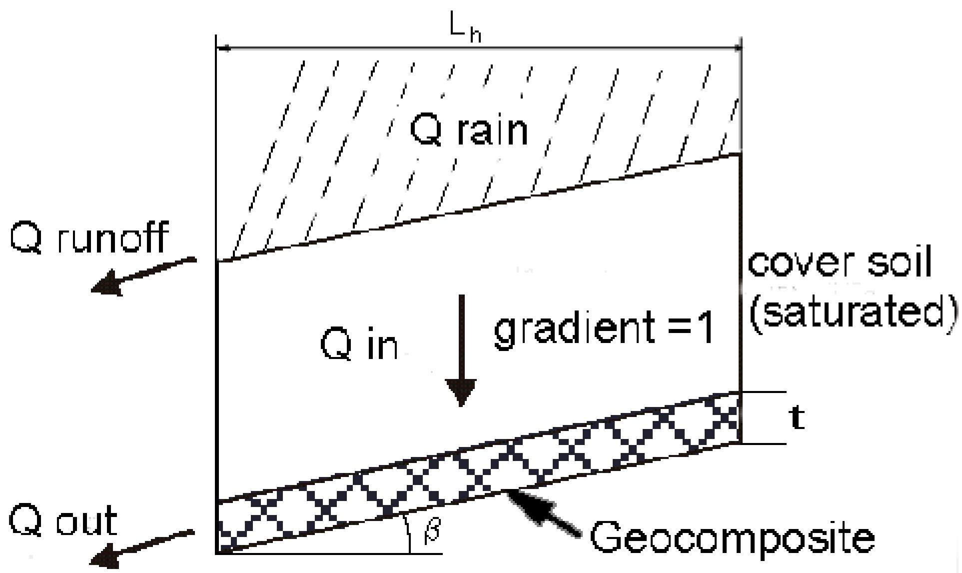
The transmissivity of a drainage geocomposite must be great enough to carry all of the infiltrating flow from the soil layer(s) above. If the drainage geocomposite can not carry all the infiltrating water (very long slope, or very permeable cover soil,...); swales can be placed as shown in the above figure. The three conditions for stability are:

1. The interface shear strength of all interfaces is adequate

2. Pore water pressures do not build up and reduce the contact stress between the geomembrane and the soil. The Seepage Force Stability Calculator can be used to determine the factor of safety of a landfill cover with consideration of seepage forces

3. Landfill gas pressures beneath the liner are vented properly.The Landfill Gas Pressure Relief Calculator can be used to determine the gas transmissivity of the relief layer. The Landfill Gas Stability Calculator can be used to verify the factor of safety of a landfill cover subject to landfill gas pressure underneath a geomembrane liner.

This webpage determines the ultimate transmissivity sufficient to transmit all incoming flow within the thickness of the geocomposite; i.e. maximum head < geonet thickness; therefore seepage forces in the cover soil will be zero.



WITH DARCY'S LAW:

$Q = k * i * A$

Inflow of water in the geocomposite

$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$

Outflow of water from the geocomposite at the toe of the slope

$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin \beta$

Inflow equals outflow (Factor of Safety = 1)

$Q_{in} = Q_{out}$

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * L_h}{\sin \beta}$$

Which results in the ultimate transmissivity after multiplying by the Total Serviceability Factor (TSF)

$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$

REQUIRED DATA

Symbol	Name	Dimensions
L_h	Drainage pipe spacing or length of slope measured horizontally	Length
k_{veg}	Permeability of the vegetative supporting soil	Length/Time

S	The liner's slope, **S** = tan **b**	-
FS_{slope}	Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces	-

FS_d	Overall factor of safety for drainage
RF_{in}	Intrusion Reduction Factor
RF_{cr}	Creep Reduction Factor
RF_{cc}	Chemical Clogging Reduction Factor
RF_{bc}	Biological Clogging Reduction Factor

Input Values

Note: If you do not wish to perform calculations for 3 cases, please leave default data as is.

	Case 1	Case 2	Case 3
S	7 %	25 %	25 %
L_h	30.5 m	62.8 m	62.8 m
k_{veg}	0.00001 cm/sec	0.00001 cm/sec	0.00001 cm/sec
FS_{slope}	1.5	1.5	1.5

Reduction Factors and Safety Factor

	Case 1	Case 2	Case 3		Surface Water Drains
RF_{in}	1.5	1.5	1.5	[1]	1.0 - 1.2
RF_{cr}	1.4	1.4	1.4	[2]	Calculate RF_{CR}
RF_{cc}	1.2	1.2	1.2	[3]	1.0 - 1.2
RF_{bc}	1.6	1.6	1.6	[3]	1.2 - 3.5
FS_d	2	2	2	[4]	2.0 - 10.0

Calculate Transmissivity

[1] Intrusion reduction factor from 100 hour to design life. Giroud et. al (2000)
[2] Creep reduction factor from 100 hour to design life (for instance, 30 years). RF_{CR} is determined from 10,000 hour compressive creep test, extrapolated to design life, GRI-GC8 (2001). RF_{CR} is product and normal load specific.
[3] GRI-GC8
[4] FS value = 2-3. Giroud, et. al (2000)
FS value > 10 for filtration and drainage. Koerner (2001)
[5] Note: The calculated transmissivity is corresponding to the case where the seating time is 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test.

Solution

Symbol	Name	Dimensions
gradient	Gradient	
$\theta_{ultimate}$	Ultimate Transmissivity	Length^2/Time
$\boldsymbol{\delta}_{\mathbf{req'd}}$		
Minimum interface friction angle	degrees	

	Case 1		**Case 2**		**Case 3**	
gradient	0.07		0.24		0.24	
$\boldsymbol{\theta}_{\mathbf{ultimate}}$	3.52E-004	**m^2/s**	2.09E-004	**m^2/s**	2.09E-004	**m^2/s**
$\boldsymbol{\delta}_{\mathbf{req'd}}$	5.99	**degrees**	20.56	**degrees**	20.56	**degrees**

Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name *		Comments	
Company			
Email Address *			
Phone			
Project Reference			

*required fields

Submit Design Results

References

"GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.

"Beyond a factor-of-safety value, i.e., the probability of failure". GRI Newsletter/Report, Vol. 15, no. 3.

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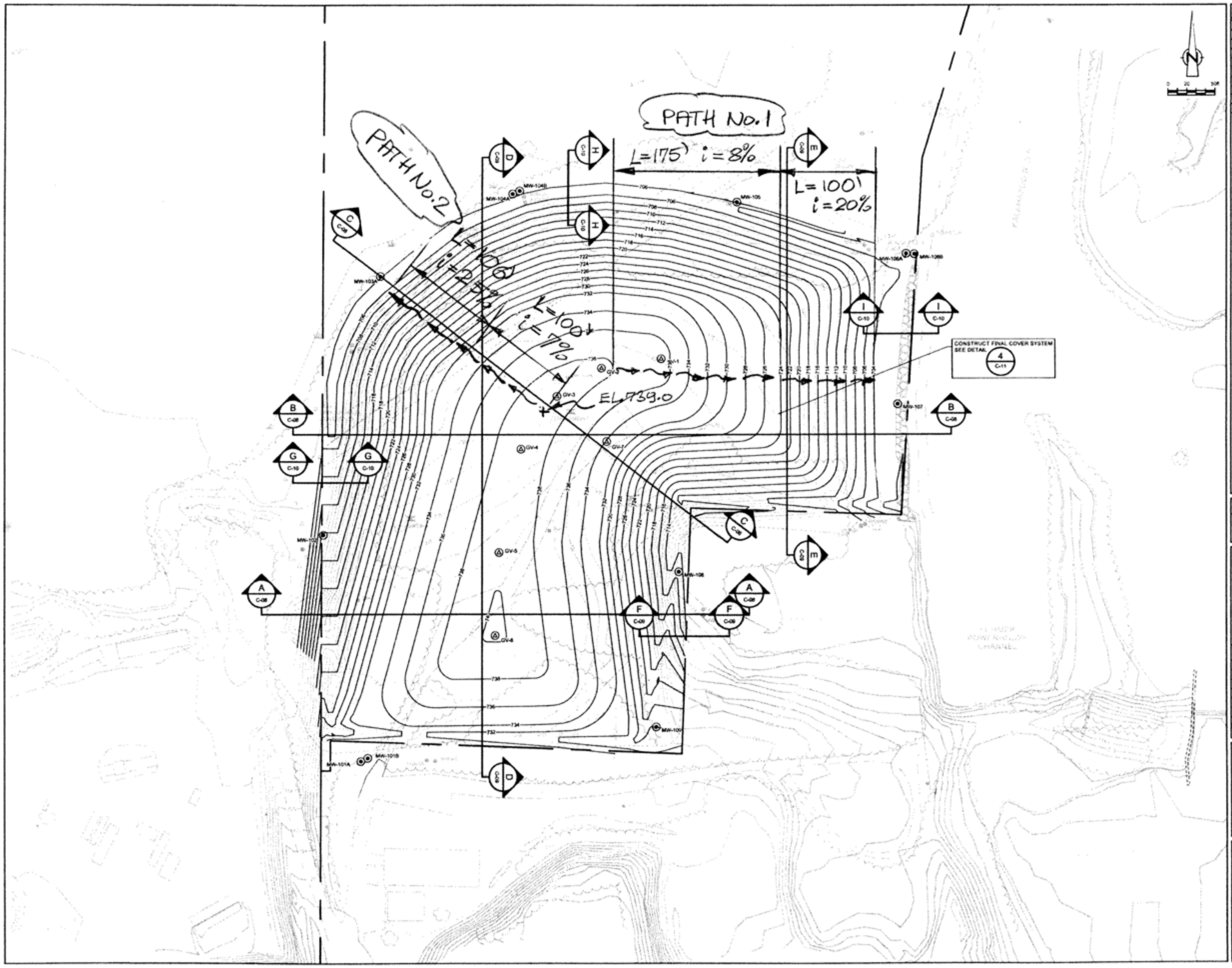
"Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". **J. P. Giroud**, **J. G. Zornberg** and **A. Zhao**, *Geosynthetics International*, Vol. 7, Nos 4-5.

"Lateral Drainage Design update - part 2". **G. N. Richardson**, J.P. Giroud and **A. Zhao**, *Geotechnical Fabrics Report*, March, 2



Nº	Revision	Date	Initial
1	UPDATED FOR SECOND EPA SUBMISSION	JUNE 15, 2009	C.R.H.

LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING FENCE
- EXISTING BUILDING
- EXISTING GROUND ELEVATION CONTOUR
- EXISTING TREES AND/OR BRUSH
- EXISTING WET AREA AND WETLAND
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- EXISTING LIMITS OF PAPER RESIDUALS
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- EXISTING INSPEC-SOL SOIL BORING LOCATION
- EXISTING VANE SHEAR TEST LOCATION
- 718 PROPOSED FINAL ELEVATION CONTOURS
- PROPOSED ROAD/DRAINAGE SWALE c/w TURF REINFORCEMENT MAT
- PROPOSED ROAD/DRAINAGE SWALE STABILIZED WITH GEOWEB
- PROPOSED GAS VENT
- MW-106B PROPOSED MONITORING WELL

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAFT

DRAWING STATUS

Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

FINAL
CONTOUR PLAN

CONESTOGA-ROVERS & ASSOCIATES

Source Reference: BASE ADAPTED FROM PREVIOUS RMT DESIGN

Project Manager: G. CARLI	Reviewed By: R. HOEKSTRA	Date: JUNE 2009	
Scale: 1" = 50'-0"	Project Nº: 56393-05	Report Nº: 004	Drawing Nº: C-07

56393-05(004)CI-WA007 OCT 16/2009

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: Weyerhaeuser Company 056393

Project: 12 ST Landfill Location: Otsego Township, Michigan

CALCULATION IDENTIFICATION

Calculation Ref. No.: ____________ No. Pages: 9
(Including calculation cover sheet)

Calculation Description:

ANNUAL SOIL LOSS FROM FINAL COVER

Design: A.Wesolowski Date: May 26/09

Checked: R. Hoekstra Date: June10/09

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)
1	06/29/09					To reflect revised contour plan
2	10/19/09					Slope revision to 4:1

CRA	PROJECT NO: 056393	DESIGNED BY: A.W.
	PROJECT NAME: 12 St Landfill	CHECKED BY: R.H.
	DATE : May 26/09	PAGE 2 OF 9

1. ANNUAL SOIL LOSS FROM FINAL COVER

1.1 Data input

- formula and factors from USEPA SW-867 "Evaluation Cover Systems for Solid and Hazardous Waste" dated Sept 1982

A = R x K x LS x C x P

Where:

A = average annual soil loss, in tons/acre
R = rainfall and runoff erosivity index, for 12 St Landfill site = 150 (fig.20)
K = soil erodibility factor in tons/acre (Table 5), for post construction conditions , sandy clay loam, organic matter 4% K= 0.21

LS = length /slope factor (Table 6) or calculated using USEPA recommended method for non-linear slope

Path	Total length Ft.	No. of segments	Slope %	LS factor	Multiplier	Corrected LS factor	Avg factor
1	275 (175+100)	2	8	1.63	0.71	1.16	
			20	6.78	1.29	8.75	**4.96**
2	206 (100+106)	2	7	1.20	0.71	0.85	
			25.0	8.40	1.29	10.84	**5.85**

C = cover management factor (Table 7), for post construction conditions, grass fully established , C = 0.01 (for meadows – grass Moderate productivity level) ,

P = practice factor (Table 8) , for post construction conditions , P = 1.0 (no support practice).

2. SOIL LOSS CALCULATIONS

Table 1 summarizes results for post construction conditions.

TABLE 1

Path No.	R	K	LS	C	P	Average annual loss tons/acre
1	150	0.21	4.96	0.01	1.0	1.56
2	150	0.21	5.85	0.01	1.0	1.84

This is an acceptable level.

United States Environmental Protection Agency
Office of Solid Waste and Emergency Response Washington DC 20460
SW-867 September 1982 Revised Edition

EPA

Evaluating Cover Systems for Solid and Hazardous Waste

Evaluate Erosion Potential   Step 18

The USDA universal soil loss equation (USLE) is a convenient tool for use in evaluating erosion potential. The USLE predicts average annual soil loss as the product of six quantifiable factors. The equation is:

$$A = R\,K\,L\,S\,C\,P$$

where A = average annual soil loss, in tons/acre
R = rainfall and runoff erosivity index
K = soil erodibility factor, tons/acre
L = slope-length factor
S = slope-steepness factor
C = cover/management factor
P = practice factor

The data necessary as input to this equation are available to the evaluator in a figure and tables included below. Note that the evaluations in Step 8 on soil composition and Steps 23-29 on vegetation all impact on the evaluation of erosion also.

Factor R in the USLE can be calculated empirically from climatological data. For average annual soil loss determinations, however, R can be obtained directly from Figure 20. Factor K, the average soil loss for a given soil in

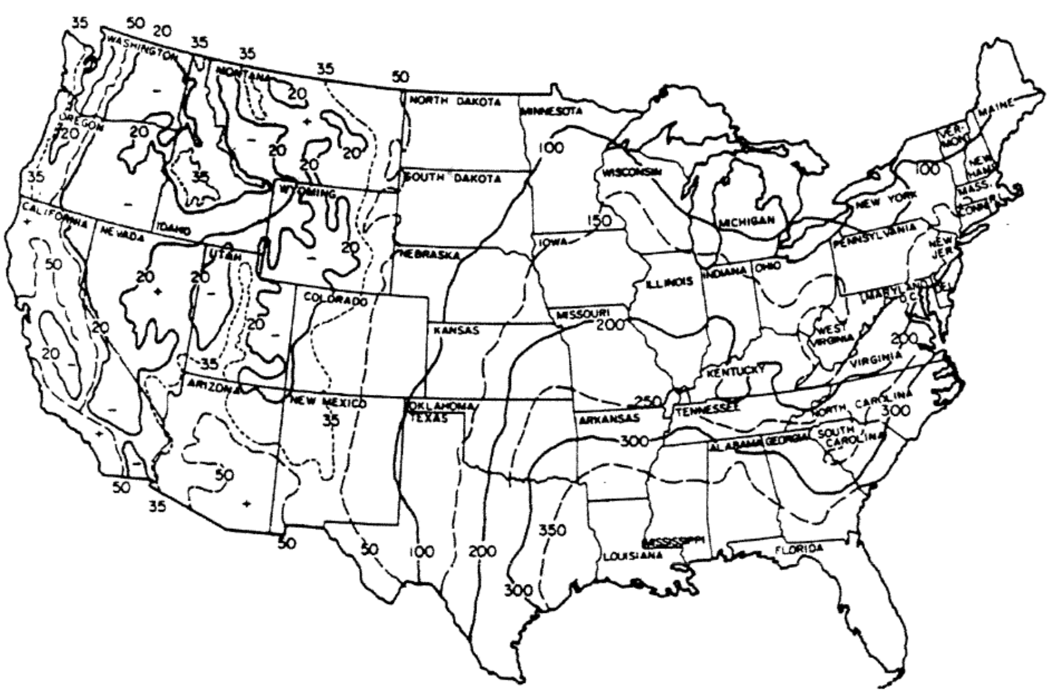


Figure 20. Average annual values of rainfall-erosivity factor R.[11]

a unit plot, pinpoints differences in erosion according to differences in soil type. Long-term plot studies under natural rainfall have produced K values generalized in Table 5 for the USDA soil types.

TABLE 5. APPROXIMATE VALUES OF FACTOR K FOR USDA TEXTURAL CLASSES[11]

Texture class	Organic matter content <0.5% K	2% K	4% K
Sand	0.05	0.03	0.02
Fine sand	.16	.14	.10
Very fine sand	.42	.36	.28
Loamy sand	.12	.10	.08
Loamy fine sand	.24	.20	.16
Loamy very fine sand	.44	.38	.30
Sandy loam	.27	.24	.19
Fine sandy loam	.35	.30	.24
Very fine sandy loam	.47	.41	.33
Loam	.38	.34	.29
Silt loam	.48	.42	.33
Silt	.60	.52	.42
Sandy clay loam	.27	.25	.21
Clay loam	.28	.25	.21
Silty clay loam	.37	.32	.26
Sandy clay	.14	.13	.12
Silty clay	.25	.23	.19
Clay		0.13-0.29	

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

The evaluator must next consider the shape of the slope in terms of length and inclination. The appropriate LS factor is obtained from Table 6. A nonlinear slope may have to be evaluated as a series of segments, each with uniform gradient. Two or three segments should be sufficient for most engineered landfills, provided the segments are selected so that they are also of equal length (Table 6 can be used, with certain adjustments). Enter Table 6 with the total slope length and read LS values corresponding to the percent slope of each segment. For three segments, multiply the chart LS values for the upper, middle, and lower segments by 0.58, 1.06, and 1.37,

TABLE 6. VALUES OF THE FACTOR LS FOR SPECIFIC COMBINATIONS OF SLOPE LENGTH AND STEEPNESS[11]

% Slope	Slope length (feet)											
	25	50	75	100	150	200	300	400	500	600	800	1000
0.5	0.07	0.08	0.09	0.10	0.11	0.12	0.14	0.15	0.16	0.17	0.19	0.20
1	0.09	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.21	0.22	0.24	0.26
2	0.13	0.16	0.19	0.20	0.23	0.25	0.28	0.31	0.33	0.34	0.38	0.40
3	0.19	0.23	0.26	0.29	0.33	0.35	0.40	0.44	0.47	0.49	0.54	0.57
4	0.23	0.30	0.36	0.40	0.47	0.53	0.62	0.70	0.76	0.82	0.92	1.0
5	0.27	0.38	0.46	0.54	0.66	0.76	0.93	1.1	1.2	1.3	1.5	1.7
6	0.34	0.48	0.58	0.67	0.82	0.95	1.2	1.4	1.5	1.7	1.9	2.1
8	0.50	0.70	0.86	0.99	1.2	1.4	1.7	2.0	2.2	2.4	2.8	3.1
10	0.69	0.97	1.2	1.4	1.7	1.9	2.4	2.7	3.1	3.4	3.9	4.3
12	0.90	1.3	1.6	1.8	2.2	2.6	3.1	3.6	4.0	4.4	5.1	5.7
14	1.2	1.6	2.0	2.3	2.8	3.3	4.0	4.6	5.1	5.6	6.5	7.3
16	1.4	2.0	2.5	2.8	3.5	4.0	4.9	5.7	6.4	7.0	8.0	9.0
18	1.7	2.4	3.0	3.4	4.2	4.9	6.0	6.9	7.7	8.4	9.7	11.0
20	2.0	2.9	3.5	4.1	5.0	5.8	7.1	8.2	9.1	10.0	12.0	13.0
25	3.0	4.2	5.1	5.9	7.2	8.3	10.0	12.0	13.0	14.0	17.0	19.0
30	4.0	5.6	6.9	8.0	9.7	11.0	14.0	16.0	18.0	20.0	23.0	25.0
40	6.3	9.0	11.0	13.0	16.0	18.0	22.0	25.0	28.0	31.0	--	--
50	8.9	13.0	15.0	18.0	22.0	25.0	31.0	--	--	--	--	--
60	12.0	16.0	20.0	23.0	28.0	--	--	--	--	--	--	--

Values given for slopes longer than 300 feet or steeper than 18% are extrapolations beyond the range of the research data and, therefore, less certain than the others.

respectively. The average of the three products is a good estimate of the overall effective LS value. If two segments are sufficient, multiply by 0.71 and 1.29.

Factor C in the USLE is the ratio of soil loss from land cropped under specified conditions to that from clean-tilled, continuous fallow. Therefore, C combines effects of vegetation, crop sequence, management, and agricultural (as opposed to engineering) erosion-control practices. On landfills, freshly covered and without vegetation or special erosion-reducing procedures of cover placement, C will usually be about unity. Where there is vegetative cover or significant amounts of gravel, roots, or plant residues or where cultural practices increase infiltration and reduce runoff velocity, C is much less than unity. Estimate C by reference to Table 7 for cover management conditions anticipated in the application, and consider changes that may take place in time. See Reference 1 for additional guidance.

Factor P in the USLE is similar to C except that it accounts for additional erosion-reducing effects of land management practices that are superimposed on the cultural practices, e.g., contouring, terracing, and

TABLE 7. GENERALIZED VALUES OF FACTOR C FOR STATES EAST OF THE ROCKY MOUNTAINS[11]

Crop, rotation, and management	Productivity level: High	Productivity level: Mod.
	C value	
Base value: continuous fallow, tilled up and down slope	1.00	1.00
CORN		
C, RdR, fall TP, conv	0.54	0.62
C, RdR, spring TP, conv	.50	.59
C, RdL, fall TP, conv	.42	.52
C, RdR, wc seeding, spring TP, conv	.40	.49
C, RdL, standing, spring TP, conv	.38	.48
C-W-M-M, RdL, TP for C, disk for W	.039	.074
C-W-M-M-M, RdL, TP for C, disk for W	.032	.061
C, no-till pl in c-k sod, 95-80% rc	.017	.053
COTTON		
Cot, conv (Western Plains)	0.42	0.49
Cot, conv (South)	.34	.40
MEADOW		
Grass & Legume mix	0.004	0.01
Alfalfa, lespodeza or Sericea	.020	
Sweet clover	.025	
SORGHUM, GRAIN (Western Plains)		
RdL, spring TP, conv	0.43	0.53
No-till pl in shredded 70-50% rc	.11	.18
SOYBEANS		
B, RdL, spring TP, conv	0.48	0.54
C-B, TP annually, conv	.43	.51
B, no-till pl	.22	.28
C-B, no-till pl, fall shred C stalks	.18	.22
WHEAT		
W-F, fall TP after W	0.38	
W-F, stubble mulch, 500 lbs rc	.32	
W-F, stubble mulch, 1000 lbs rc	.21	

Abbreviations defined:

B - soybeans
C - corn
c-k - chemically killed
conv - conventional
cot - cotton
F - fallow
M - grass & legume hay
pl - plant
W - wheat
wc - winter cover

lbs rc - pounds of crop residue per acre remaining on surface after new crop seeding
% rc - percentage of soil surface covered by residue mulch after new crop seeding
70-50% rc - 70% cover for C values in first column; 50% for second column
RdR - residues (corn stover, straw, etc.) removed or burned
RdL - all residues left on field (on surface or incorporated)
TP - turn plowed (upper 5 or more inches of soil inverted, covering residues)

contour strip-cropping. Approximate values of P, related only to slope steepness, are listed in Table 8. These values are based on rather limited field data, but P has a narrower range of possible values than the other five factors.

TABLE 8. VALUES OF FACTOR P[11]

Practice	Land slope (percent)				
	1.1-2	2.1-7	7.1-12	12.1-18	18.1-24
	(Factor P)				
Contouring (P_c)	0.60	0.50	0.60	0.80	0.90
Contour strip cropping (P_{sc})					
R-R-M-M[1]	0.30	0.25	0.30	0.40	0.45
R-W-M-M	0.30	0.25	0.30	0.40	0.45
R-R-W-M	0.45	0.38	0.45	0.60	0.68
R-W	0.52	0.44	0.52	0.70	0.90
R-O	0.60	0.50	0.60	0.80	0.90
Contour listing or ridge planting (P_{cl})	0.30	0.25	0.30	0.40	0.45
Contour terracing (P_t)[2]	[3] $0.6/\sqrt{n}$	$0.5/\sqrt{n}$	$0.6/\sqrt{n}$	$0.8/\sqrt{n}$	$0.9/\sqrt{n}$
No support practice	1.0	1.0	1.0	1.0	1.0

[1] R = rowcrop, W = fall-seeded grain, O = spring-seeded grain, M = meadow. The crops are grown in rotation and so arranged on the field that rowcrop strips are always separated by a meadow or winter-grain strip.

[2] These P_t values estimate the amount of soil eroded to the terrace channels and are used for conservation planning. For prediction of off-field sediment, the P_t values are multiplied by 0.2.

[3] n = number of approximately equal-length intervals into which the field slope is divided by the terraces. Tillage operations must be parallel to the terraces.

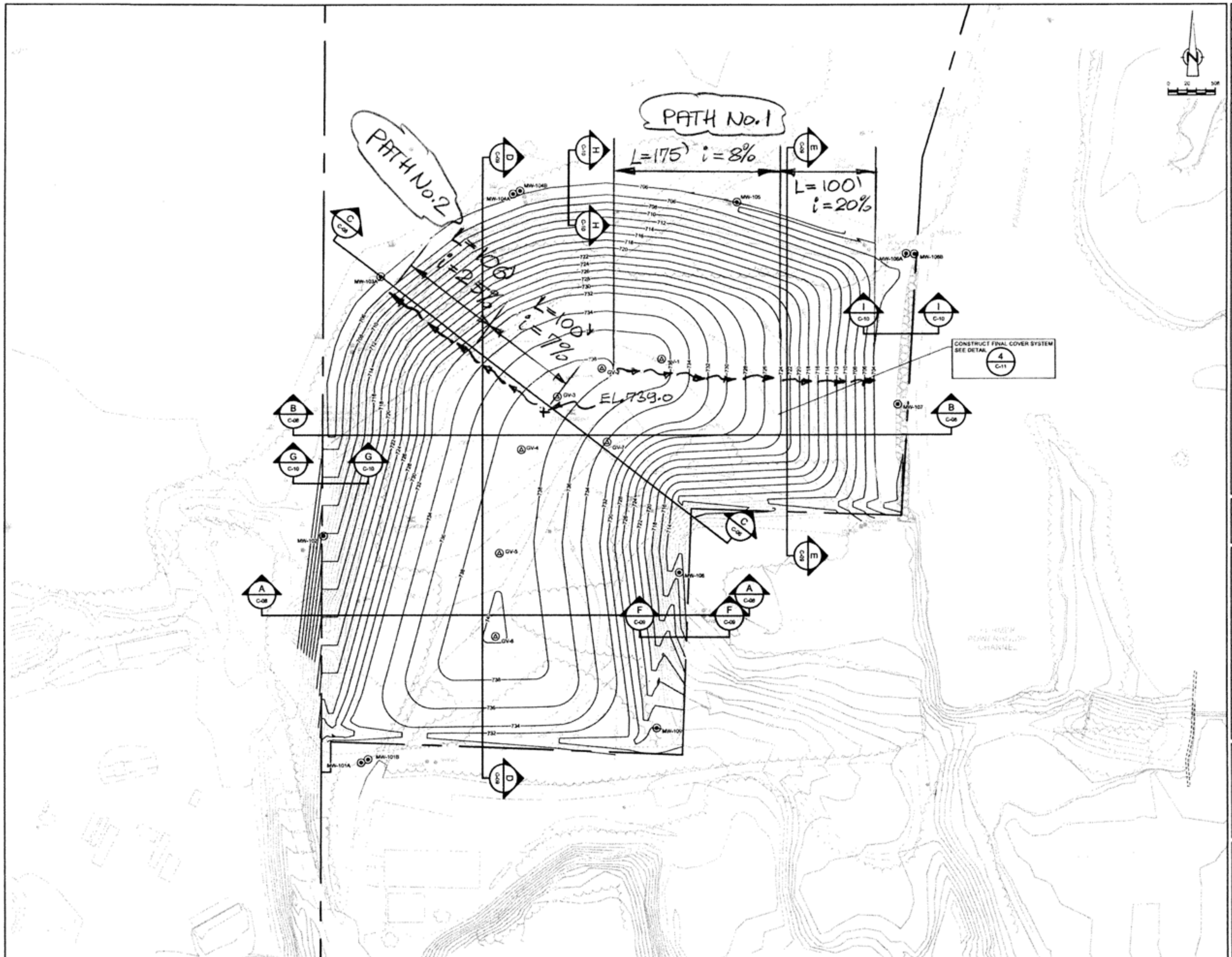
Example: An owner/operator proposes to close one section of his small landfill with a sandy clay subsoil cover having the surface configuration shown in Figure 21. The factor R has been established as 200 for this locality. The evaluator questions anticipated erosion along the steep side and assigns the following values to the other factors in the USLE after inspecting Tables 5 through 8:

$$K = 0.14 \quad LS = 8.3 \quad C = 1.00 \quad P = 0.90$$

The rate of erosion for the steep slope of the landfill is calculated as follows:

$$A = 200\ (0.14 \text{ tons/acre})\ (8.3)\ (1.00)\ (0.90) = 209 \text{ tons/acre}$$

This erosion not only exceeds a limit recommended by the permitting authority but also indicates a potential



Nº	Revision	Date	Initial
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SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved:

DRAFT

DRAWING STATUS

Status	Date	Initial

12th STREET LANDFILL
Otsego Township, Michigan

PRE-FINAL DESIGN REPORT ADDENDUM No. 1

FINAL
CONTOUR PLAN

CONESTOGA-ROVERS & ASSOCIATES

Source Reference: BASE ADAPTED FROM PREVIOUS RMT DESIGN

Project Manager: G. CARLI	Reviewed By: R. HOEKSTRA	Date: JUNE 2009	
Scale: 1" = 50'-0"	Project Nº: 56393-05	Report Nº: 004	Drawing Nº: C-07

56393-05(004)CI-WA007 OCT 16/2009

APPENDIX P

AUTOCAD CIVIL 3D 2009 VOLUME CALCULATION SUMMARY

056393-05

Surface Report

Client: 12th **STREET LANDFILL**

Project Name: P:\drawings\56000s\56393\56393-(C3D)\56393-00(C3D002)\Working Drawings\56393-05(C3D002)CI-WA004.dwg

Project Description:

Report Date: 10/19/2009 1:53:07 PM

Prepared by:

Linear Units: foot	**Area Units:** squareFoot	**Volume Units:** cubicYard

Surface: 05-2009-10-16-pr-subgrade-volume
Description: Description

Area 2D: 288603.97568328766	Area 3D: 296534.4090794666
Elevation Max: 14.525220270677	Elevation Min: -18.518128270117
Number of Points: 92898	Number of Triangles: 184646

Volume Surface: 05-2009-10-16-pr-subgrade-volume
Description: Description

Volume Cut: 21578.917014184095	Volume Fill: 35870.198648397694	Volume Total: 14291.281634213434
Compare Surface: 05-2009-10-16-pr-subgrade Base Surface: existing-grade		